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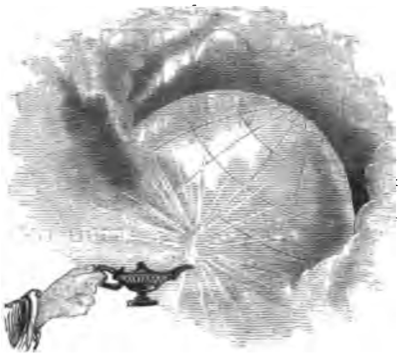

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PREFACE.

It is hardly necessary, at the present time, to vindicate the right of Physical Geography to a prominent place among the studies pursued in our schools, academies, and higher institutions of learning; for our best educators now appreciate its importance, and regard it as a constituent part of the science of Geography.

In the following work the writer has endeavored to unfold concisely, yet in their completeness, the principles and facts of Physical Geography, and has sought, by the mode of presenting them and by freshness of illustration, to uphold the intrinsic interest of this department of science. In respect to the arrangement of the several divisions of the subject, their natural and obvious order has been adopted.

In the preparation of this treatise the standard works on Physical Geography have been consulted,—such as the splendid folio Atlas of Johnston, that of Petermann and Milner, and the treatises of Humboldt, Herschel, Somerville, Ansted, and others. Recourse has also been had to the United States Explorations and Surveys, Maury's Nautical Charts and Sailing Directions, various Encyclopædias, numerous scientific works, and books of travels and researches. In fine, from all sources, both public and private, which have been accessible to the author, facts and illustrations have been drawn.

The attention of the student is directed throughout the subject to the truth that the globe is not a mere collection of matter existing under various forms, but an *organized body*, filled with a wondrous mechanism, in which all the parts and systems are exquisitely adapted to each other; and that the physical phenomena of the world reveal in their harmonious action a unity of plan and purpose, and display in an infinite variety of ways the Power, Wisdom, and Goodness of the Almighty Designer.

TRINITY COLLEGE, December 2, 1867.

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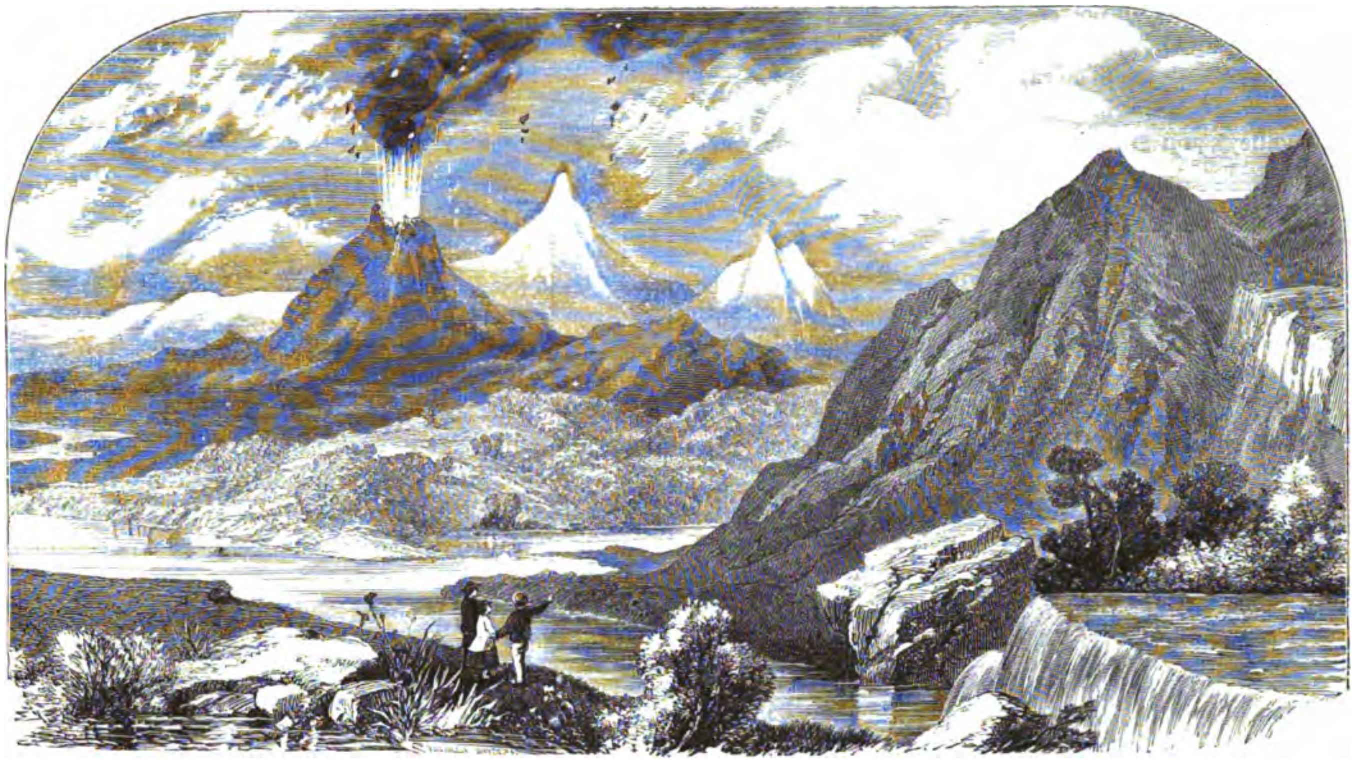
PHYSICAL GEOGRAPHY.



INTRODUCTION.

1. Physical Geography is that science which treats of the surface and atmosphere of the Earth, with its various forms of life and the laws of their distribution. Its limits, however, are not rigorously defined, inasmuch as our knowledge of the existing condition of the globe must evidently be imperfect unless we are somewhat acquainted with its previous history, and are aware of the mighty convulsions through which it passed before it received its present organization and became fitted for the abode of man.

2. Nor must the connection of the earth with the solar system be forgotten; for the secret influences of the sun control its motions, quicken its countless germs of life, and fill it with abundance and beauty. The department of science under consideration, therefore, extends, more or less, into the domains of Astronomy and Geology.

3. Physical Geography is embraced under six general divisions, to wit:—

I. The Earth regarded as a Planet.
II. The Structure and Formation of the Earth.
III. The Land.
IV. The Water.
V. The Atmosphere and its Phenomena; or, Meteorology.
VI. The Life of the Globe, and its Distribution.

---

1. Of what does Physical Geography treat? Why are not its limits rigorously defined? 2. What connection has the earth with the solar system? What sciences are connected with Physical Geography? 3. Under what general divisions is Physical Geography embraced?

PART FIRST.

THE EARTH REGARDED AS A PLANET.

CHAPTER I.

1. **The Earth** is one of the planets[1] of the solar system, and the third, so far as we know, in the order of distance from the sun.

2. **Form of the Earth.**—The earth appears, at the first view, to be nothing more than a vast broken plain, swelling into mountains, sinking into valleys, and spreading out into lakes, seas, and oceans; but careful researches have removed this erroneous impression, and proved, beyond a doubt, that it is nearly *spherical* in form. The proofs are as follows:—

I. When a vessel sailing from the shore speeds over the ocean, and gradually lessens in the distance, her hull first sinks below the horizon, the lower sails next disappear, and the last objects seen are the tops of the masts.

II. Navigators have repeatedly sailed around the earth by constantly advancing in the same direction, arriving at length at the port from whence they departed.

III. The visible portion of the earth's surface is always *circular*, wheresoever an observation is taken. That this fact proves the earth to be spherical will be evident from the following illustration. If we take an orange to represent the earth, and cut a smooth slice from any side of it, the outer surface of the slice may be considered as the portion of the surface of the earth seen at any time by a spectator.

The bounding line of this surface is seen at a glance to be the *circumference* of a circle. If, instead of a spherical body, like an orange, a lemon is taken, and a slice cut from the side, the shape of the slice will be *oval*. In a lunar eclipse the shadow of the earth is cast upon the moon, and appears *circular*.

IV. We have said that the earth is *nearly* spherical. If it were a sphere, the length of a degree would be the same in every latitude; but the various measurements of arcs of meridians, made by astronomers, in different parts of the world, with wonderful accuracy, all show that a degree increases in length from the equator to the poles. This fact proves that the earth is flattened at the poles; and to such a solid, mathematicians give the name of an *oblate spheroid*.

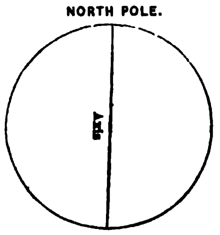
The varying rates of the vibrations of a pendulum in different latitudes establish the same point.

3. **Size of the Earth.**—It has been found from the most recent researches and calculations that the *equatorial*[2] *diameter* of the earth is 7926.708[3] miles, and the *polar*[4] *diameter* 7899.755 miles,—the difference being 26.953 miles. The length of the equatorial circumference is 24,902.487 miles.

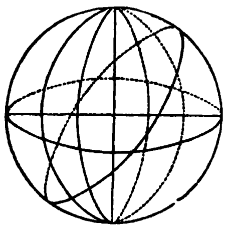
4. **Terrestrial Sphere.**—For the purposes of description and of fixing the positions of places, geographers have conceived the earth to be divided by certain imaginary lines, and the globe thus intersected is called the *terrestrial sphere*. These lines are the *axis*, *meridians*, *equator*, *parallels of latitude*, *tropics*, and *polar circles*.

5. **Axis of the Earth.**—The axis of the earth, or polar diameter, is that diameter upon which it revolves, as will be presently shown. Its northern extremity is the north pole of the earth, and its southern is the south pole.

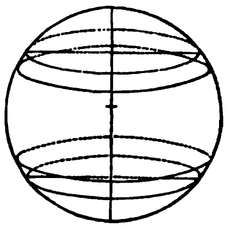
The position of the earth's axis determines that of each of the other fictitious lines. Every plane passing through the centre of the earth divides it into two equal parts, termed *hemispheres*, and its section is called a *great circle*. All other sections are *small circles*, and divide the earth into unequal parts. The circumferences of all circles, great or small, are divided into three hundred and sixty equal parts, called *degrees*, each degree into sixty equal parts, called *minutes*, and each minute into sixty equal parts, called *seconds*. Degrees are designated by the following character, °; minutes, thus, ′; seconds, thus, ″.



SOUTH POLE.

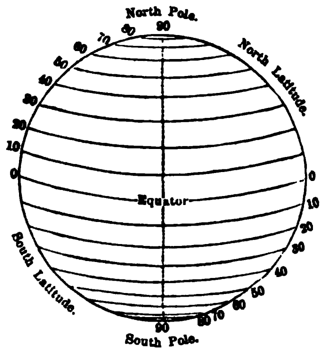


GREAT CIRCLES.

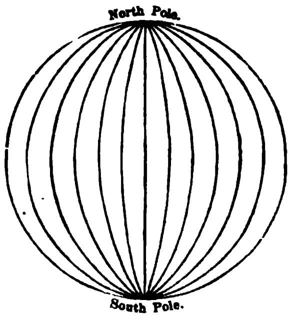


SMALL CIRCLES.

6. **The Equator** is a great circle perpendicular to the axis, extending east and west, and dividing the globe into hemispheres, the *northern* and *southern;* any diameter in its plane is an equatorial diameter. *Meridians* are *great circles* passing through the poles of the earth perpendicular to the equator. *Parallels of latitude* are *small circles* parallel to the equator. Of these, two are termed *tropics*, and two others, *polar circles*.



PARALLELS OF LATITUDE.



MERIDIANS.

The tropic of Cancer is about 23° 27′ north of the equator, and the tropic of Capricorn about 23° 27′ south of the equator. The north polar, or Arctic, circle is about 23° 27′ from the north pole, and the south polar, or Antarctic, circle about 23° 27′ from the south pole.

7. **Zones.**—Zones are those divisions of the earth's surface which are included between the tropics, the tropics and the polar circles,

---

[1] From the Greek word *planētes*, *a wanderer;* a heavenly body that changes its place.

[2] See Articles 5 and 6.

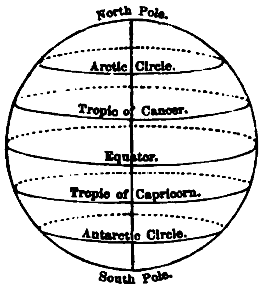
[3] The English *statute* mile is 1760 yards long; the English *geographical* mile is *one-sixtieth* of a degree of latitude, and about 2025 yards in length,—*one-seventh* greater than the former. In this work, wherever the words *mile* and *miles* occur without any designation, the English statute mile is understood.

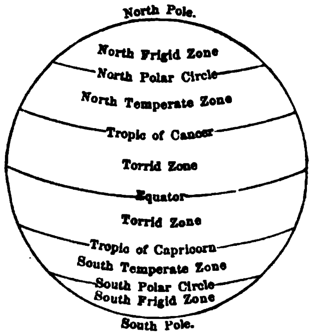
[4] See Articles 5 and 6.

---

1. What is said of the earth, and of its position in the solar system? 2. What is the form of the earth? Give the proofs. Is the earth a sphere? What is its true form, and how proved? 3. Give the length of the equatorial diameter. That of the polar. Give the length of the equatorial circumference. 4. What is the terrestrial sphere? What are the principal imaginary lines of the earth? 5. What is the axis of the earth? What are the poles? What does the position of the axis determine? How is the globe divided by a plane passing through its centre? What are great circles? Small circles? How are the circumferences of all circles divided and subdivided? 6. What is the equator? What are meridians, parallels of latitude, tropics, and polar circles? What are the respective positions of the tropics, and of the polar circles? 7. What are zones, and how many are there?

and the polar circles and the poles. They are five in number: the space between the tropics is called the *torrid zone;* that included by the tropics and polar circles, the *north temperate* and the *south temperate zone;* and the remaining surface, lying between the two poles and the polar circles, are severally named the *north frigid* and the *south frigid zone.*





The zones have received their respective appellations on account of the different degrees of heat they receive from the sun. The cause of this will be evident when we speak of the *seasons.*

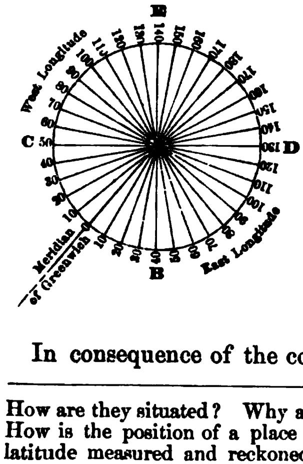
8. **Latitude and Longitude.**—The position of a place on the earth's surface is determined by its *latitude* and *longitude.* The *latitude* of any place is its distance from the equator, measured, in degrees, minutes, and seconds, on a meridian passing through the place. Latitude is reckoned north and south from the equator to the poles, —a distance of 90 degrees.

Regions north of the equator are in north latitude, and those south of the equator in south latitude. If two or more places are situated, for instance, on the 20th degree of south latitude, they are said to be on the same parallel, because the same circle passes through them. Degrees of latitude increase in length from the equator to the poles, the length of a degree at the equator being 68.7 miles, but at the poles, 69.4 miles.

The longitude of any place is the distance between a meridian passing through that place, and another meridian, taken as a standard, this distance being measured on the equator in degrees, minutes, and seconds.

The standard meridian of the early geographers passed through the isle of Ferro,—one of the most westerly of the Canary Isles.

In most of the kingdoms and states of Europe, that meridian is taken as a standard which passes through their principal observatory. Thus, the French reckon longitude from the observatory of Paris, and the English from that of Greenwich, which is the standard generally adopted in America.



Longitude is reckoned east and west from the standard meridian, being measured in each direction from 0° to 180°. Places lying west of the assumed meridian are said to be in *west* longitude, up to 180°; those to the east, in *east* longitude, to the same extent.

This point is illustrated in the annexed figure, where the circle CEDB represents the equator, and A the pole of the earth.

In consequence of the convergence of the meridians to the poles, degrees of longitude vary in length at different latitudes. Thus, at the equator the extent of a degree is about 69 miles; at the 20th parallel, nearly 64.8 miles; at the 40th, about 52.8 miles; and at the 80th parallel, only 12 miles; vanishing to nothing at the poles.

9. **Motions of the Earth.**—The earth has two motions: *first,* a *daily* revolution about its axis from west to east, causing the grateful vicissitudes of day and night; and, *secondly,* a *yearly* revolution around the sun in the same direction, which gives rise to the changing seasons.

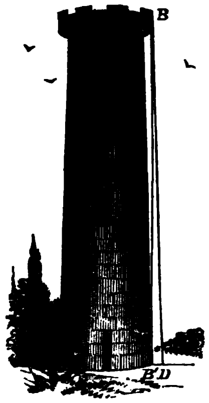
These views were held by Pythagoras, a Greek philosopher, five hundred years before the Christian era, but were rejected by succeeding astronomers, who regarded the earth as stationary, around which all the heavenly bodies were supposed to revolve every twenty-four hours. This error continued for about two thousand years, when the true theory was revived by Copernicus, in the sixteenth century.

10. **Daily Motion.**—The fact that the earth revolves upon its axis rests upon the following proofs:—

I. It is impossible, from the laws of centrifugal force, that the heavenly bodies should revolve daily about the earth; but perfectly consistent with these laws to consider their motion as *apparent,* and due to a *real* motion of the earth.

II. The flattening of the earth at its poles is the legitimate effect of its rotation. Newton, assuming the earth to revolve upon its axis, proved its figure to be that of an oblate spheroid, before the fact was shown by actual measurements.

III. Balls descending from the summit of a high tower fall *east* of the point whence they started; the top of the tower, and of course the balls, moving more rapidly eastward than the base, as they are farther from the axis of the earth than the latter, and consequently have a greater centrifugal force. In 1804, thirty balls were dropped from Michael's Tower, in Hamburg, from the height of 235 feet, when the deviation from a perpendicular was found to be *one-third* of an inch. The annexed cut illustrates this proof. A ball being dropped from B does not take the direction of the perpendicular BB′, but that of the inclined line BD.



IV. The diminished weight[1] of bodies at the equator indicates a centrifugal force resulting from the rotation of the earth. A body removed from the poles to the equator would lose by this force $\frac{1}{289}$th of its weight.

V. The pendulum experiment of Foucault proves the daily motion of the globe.

VI. All the planets, that afford the astronomer any means of determining the question, are found to revolve on their axes; and it is reasonable to infer that the earth, which belongs to the same system, also revolves on its axis.

This axis is its shortest or polar diameter, the length of which, as already stated, is 7899.7 miles. Upon no other diameter can the globe permanently rotate: every other is unstable; for if a globe begins to revolve on any diameter except the shortest, it changes its rotation till it eventually revolves on the latter. The velocity of the earth on its axis is about 1000 miles an hour at the equator.

---

[1] A body removed from the equator to the poles gains $\frac{1}{194}$th of its entire weight; $\frac{1}{590}$th is due to the flattening of the earth at the poles. The difference between $\frac{1}{194}$th and $\frac{1}{590}$th, equal to $\frac{1}{289}$th, still remains to be accounted for; and the rotation of the earth does account for it.

How are they situated? Why are the zones termed torrid, temperate, and frigid? How is the position of a place on the earth's surface determined? 8. How is latitude measured and reckoned? Are the degrees of latitude all of the same length? What is longitude, and how measured? What is said of the standard meridian? How is longitude reckoned? What is said respecting the length of a degree of longitude? Give instances. 9. How many motions has the earth? What were the views of Pythagoras? What those of succeeding astronomers? When was the true theory of the earth's motions revived? 10. Give the proofs of the earth's rotation. Upon what diameter does the earth revolve? Can it revolve permanently on any other? What is the velocity of the earth on its axis?

11. **Annual Motion.**—The annual revolution of the earth around the sun is inferred from the following considerations:—

I. From the fact that all the other bodies of the solar system possess this motion, and there is no reason for believing that the earth constitutes an exception.

II. The *squares* of the *times* of the revolutions of the planets about the sun are proportional to the *cubes* of their average *distances* from this orb. The earth, on the supposition that it is in motion around the sun, is included in this law.

III. The phenomenon termed the aberration of light can be explained only by the annual motion of the earth.

12. **The Ecliptic** is the orbit, or path, which the earth describes in its yearly revolution, and is so named because the *eclipses* of the sun and moon happen in, or near, its plane. The distance of the earth from the sun is 95,300,000 miles; the length of its orbit, 598,000,000 miles; and its orbitual velocity, 1138 miles a minute.

13. **The Seasons.**—The change of seasons is owing to three causes:—

I. That the sun illumines but half of the globe at a time.

II. That the axis of the earth is inclined to the plane of the ecliptic.

III. That the direction of the axis is always the same. The inclination of the axis to a perpendicular to the ecliptic is about 23° 27′.

On the 20th of March the direction of the sun's rays is perpendicular to the earth's axis, and the bounding line that divides the enlightened from the dark hemisphere, and which is called the *circle of illumination*, reaches from pole to pole. As the earth revolves on its axis, every place on its surface is now half the time of one rotation in darkness, and the other half in light; and the days and nights are equal in length all over the globe. This is the time of the vernal equinox[1] in the northern hemisphere, and of the autumnal in the southern,—spring beginning in the former and autumn in the latter.

The earth moving on its course, the circle of illumination gradually overlaps the north pole more and more, and recedes from the south pole,—the days increasing in length and the nights decreasing, in the northern hemisphere, and the reverse occurring in the southern.

On the 21st of June the circle of illumination reaches its utmost limit, the rays of the sun then extending 23° 27′ beyond the north pole to the Arctic circle, and falling short of the south pole by the same amount, just grazing the Antarctic circle. Within the former circle now reigns continual day, and within the latter unbroken night.

In the northern hemisphere it is the beginning of summer, and the time of the summer solstice,[2] when the day is longest and the night shortest. In the southern hemisphere it is the period of the winter solstice, when winter commences, and the night is longest and the day shortest.

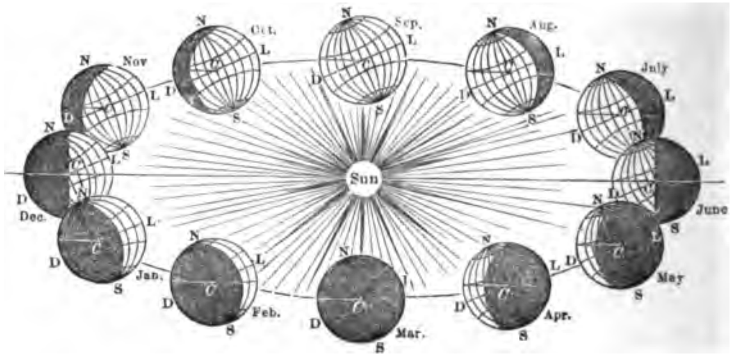
As the earth departs from the summer solstice, the circle of illumination returns by degrees to the north and south poles, shortening the days and lengthening the nights in the northern hemisphere, and producing the contrary effects in the southern.

On the 22d of September it again passes through the poles, when the days and nights are once more equal in length all over the world. This is the time of the autumnal equinox in the northern hemisphere, and of the vernal in the southern,—spring commencing in the latter region, and autumn in the former.

The earth still sweeping forward in its annual course, the circle of illumination gradually withdraws from the north pole, and extends beyond the south pole, lengthening the nights and shortening the days in the northern hemisphere, and causing the opposite results in the southern.

On the 21st of December this change has attained its full extent: the rays of the sun then strike the earth beyond the south pole to the Antarctic circle, and the regions within this circle now enjoy a continual day; but in the northern hemisphere the solar beams reach only the Arctic circle, and this zone is now veiled in the gloom of a constant night.

It is now the time of the winter solstice in the northern hemisphere, when winter begins, and of the summer solstice in the southern, when summer opens,—the longest day now occurring in the latter hemisphere, and the shortest in the former.



' The subject of seasons is illustrated by the annexed cut, where the twelve globes represent the position of the earth in its orbit in the successive months of the year, DCL the equator, and NCS the axis,—N being the north pole, and S the south.

14. **Solar Influences.**—The sun, by its attraction, keeps the earth in her orbit, and, in conjunction with the moon, sways in tides the waters of the ocean.

His beams illumine the globe in its ceaseless circuit, transforming, by their manifold powers, what would otherwise be a mass of dead and inert matter into a world glorious in life, grandeur, and beauty.

The sunbeam, by its chemical power, its light and heat, moulds the crystal, wakens the sleeping seed, and, quickening the pulse of life throughout the world, clothes it with verdure, bud, bloom, and fruit, all glowing with the rich and varied hues of light, while every form of animal life rejoices beneath its cheering rays.

Moreover, by its heat, it lifts the waters into the air, to descend in fertilizing showers, and gives rise to the winds which distribute the treasures of rain all over the world. Such are a few of the influences of the sun, which will be more fully unfolded in the subsequent chapters of this work; for the energies of this mighty orb pervade all the realms of nature embraced by the subject of Physical Geography.

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[1] From the Latin *æquus*, equal, and *nox*, night.

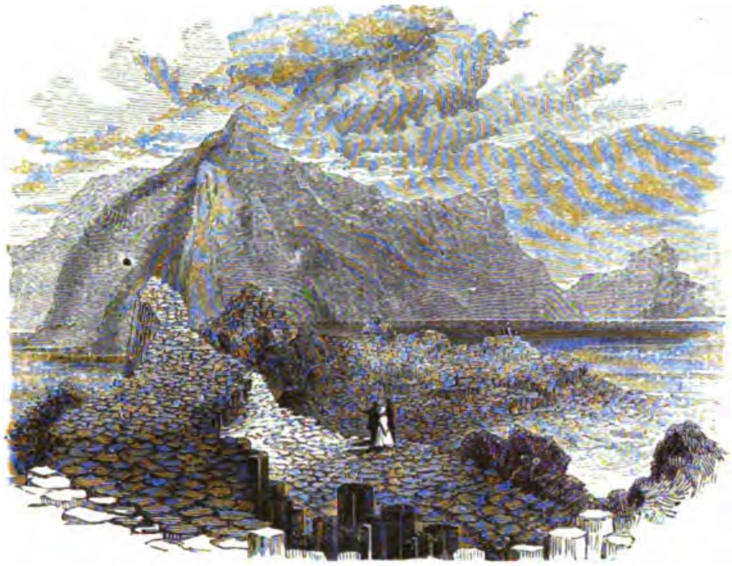
[2] From the Latin *sol*, sun, *stare*, to stand; because the sun now appears to be stationary in the heavens, as regards its apparent motion north or south.

11. Give the proofs of the annual motion of the earth. 12. What is the ecliptic? What is the distance of the earth from the sun, the length of its orbit, and its orbitual velocity? 13. To what are the seasons owing? What is the inclination of the earth's axis to a perpendicular to the ecliptic? Describe in full the changes of the seasons. Explain the seasons by the cut. 14. What is said of the influence of the sun upon the earth?

PART SECOND.

THE STRUCTURE OF THE EARTH.

1. **The subject of the Structure of the Earth** may be appropriately divided into two heads:—1st. The Central Mass of the Earth, and its Crust. 2d. The Formation of the Earth.



BASALTIC COLUMNS, GIANTS' CAUSEWAY, IRELAND.

CHAPTER I.

OF THE CENTRAL MASS OF THE EARTH, AND ITS CRUST.

2. **The Earth** consists of a rocky shell, called its *crust*, and of a fiery central mass, either solid or fluid.

3. **Central Mass.**—That the interior of the earth is intensely heated is inferred from the following facts. In the first place, it has been observed that in all deep mines the temperature of the rock increases 1° Fah.[1] for every fifty or sixty feet of descent, after the first hundred feet. This is true in all parts of the world, and in every kind of rock through which the mine passes.

In the next place, water that flows from Artesian[2] wells increases in temperature with the depth of the latter. The water from the well of Grenelle, at Paris, which rises from a depth of 1798 feet, has a constant temperature of nearly 82° Fah.; while the mean temperature of the air in this city is only 53° Fah. The temperature of the water, therefore, increases, on an average, 1° Fah. for every sixty-two feet of descent.

Very accurate observations on this point have lately been made by Walferdin, on two Artesian wells at Creuzot, in France. The borings were a mile apart, and began at the height of 1030 feet above the sea-level, one descending 1900 feet, and the other 2678 feet. After the utmost precautions were taken to insure correctness, the results showed that, to the depth of 1800 feet, the temperature rose at the mean rate of 1° Fah. for every fifty-five feet of descent, after which the change was more rapid, being 1° Fah. every forty-four feet.

The hot springs that occur in various parts of the globe, and which are generally found to have their sources very deep below its surface, attest likewise the existence and progressive increase of its internal heat.

But, above all, volcanoes, which in every clime are seen, from time to time, pouring out their fiery streams of melted rock, exhibit the most striking proof of the intense heat of the central portions of the earth. According to Humboldt, granite would be melted at the distance of about twenty-four miles below the surface of the earth, if the temperature constantly increased to this depth at the rate of 1° Fah. for every fifty-four and a half feet.

4. **The Earth's Crust.**—Deep mines and borings have been sunk in different parts of the globe, revealing its structure; but none have pierced further than about two thousand feet below the sea-level. The greatest depth thus attained is, perhaps, at the salt-works at Minden, in Prussia, where the boring sinks 1970 feet beneath the level of the ocean.

Greater absolute depths have been reached in mines beginning at higher places: thus, the old mine at Kuttenberg, in Bohemia, probably the deepest in the world, descended to the depth of 3545 feet; yet its bottom is above that of the mine of Minden.

Our knowledge of the earth's structure extends, however, beyond the depth of two thousand feet, for powerful internal forces have so tilted and bent the lower rocky strata that they lie at or near the surface in inclined and curved positions, and geologists have thus been enabled to study the nature of the globe to the depth of *sixteen miles.* The discoveries which have been made show that the earth's crust consists of various kinds of rocks, arranged in a fixed order.

Under the name of rocks are included not only compact masses, but beds of clay, gravel, sand, marl, and so forth.

The chemist has proved that the materials revealed consist, at the most, of *sixty-five* elementary bodies, and that sixteen of these, united in different combinations and proportions, form nearly all the known matter of the globe. These important elements are silicum, alumi-

TILTED STRATA OF RED SANDSTONE, LAKE SUPERIOR.

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[1] 1° Fah. means one degree of temperature according to Fahrenheit's thermometer.

[2] By boring into the earth deep enough to reach a subterranean body of water, whose sources are higher than the place of the perforation, a spring or well is obtained, called an *Artesian* well, because such wells were first made in Artois, in France.

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1. What is the subject of Part Second? How is this subject divided? What does Chapter I. treat of? 2. What does the earth consist of? 3. Give the proofs for the intense heat of the central mass, and detail the observations and experiments cited. What is said of hot springs and volcanoes? State the remark of Humboldt.

4. How do we obtain any knowledge of the nature of the earth's crust? To what depth has it been studied? Of what does the earth's crust consist? What is understood by the word rocks? How many elementary bodies are there? Mention the most important in this connection.

num, potassium, sodium, magnesium, calcium, iron, manganese, oxygen, hydrogen, nitrogen, carbon, sulphur, chlorine, fluorine, and phosphorus.

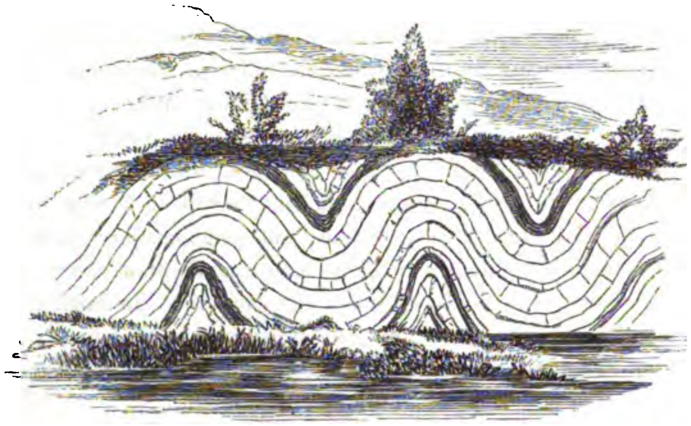
Oxygen, combined with the first six of these elements, termed metalloids, comprises the greater portion of the rocks, and is regarded as constituting in itself from a half to a third of the whole crust of the globe. United with hydrogen it forms water, and with nitrogen the atmosphere. By weight it constitutes *eight-ninths* of all the waters of the earth, and *one-fifth* of the atmosphere.

Oxygen is essential to animal life, and to combustion. Iron is the most valuable of all the metals.

Carbon forms a considerable portion of all vegetation: coal chiefly consists of it, and it enters largely into the composition of limestone and marble. The brilliant diamond is nothing more than pure, crystallized carbon.

To silicum we are indebted for glass; and chlorine, in combination with sodium, gives us that most useful article, salt.

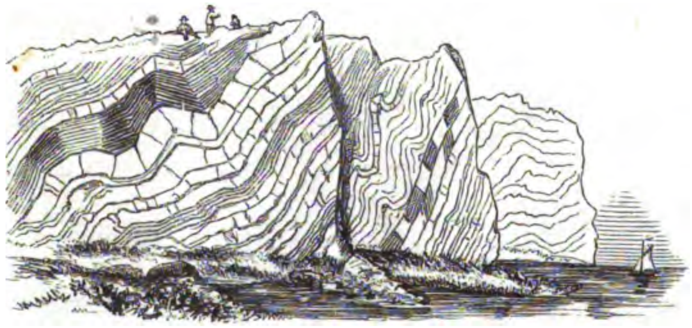
5. **Rocks Classified.**—Rocks are divided into three great classes, —*stratified*,[1] *unstratified*, and *metamorphic*.[2]



CURVED STRATA.

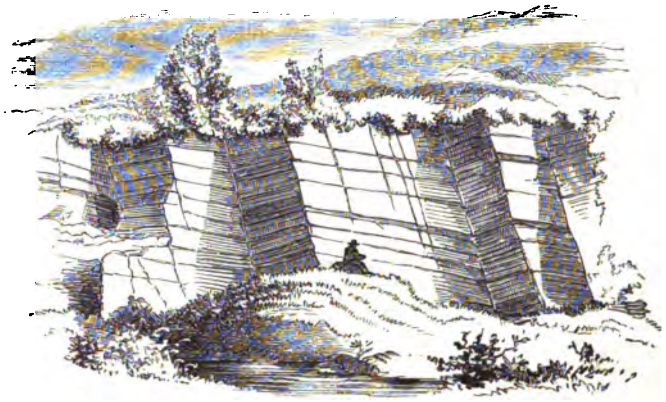
6. **Stratified Rocks.**—Stratified rocks are composed of layers, parallel to each other, in *curved*, *inclined*, or *horizontal* positions.

They have evidently been formed through the action of water by the successive deposits of sediment, and have therefore received the name of *aqueous* rocks. Sandstone, clay, and limestone are included in this class.



INCLINED STRATA.

All along the past ages the elements have been incessantly at work, wearing away the land. Frost and heat have disintegrated the rocks, and enormous glaciers ground them to powder; the rains, rivers, and ocean have washed, channelled, and chafed the earth, and its finer particles have been deposited by their action in the bottoms of lakes and seas, where they have become consolidated into rocky, horizontal beds. But these have not remained at rest; for the contraction resulting from the cooling of the globe has bent them into vast folds, forming hills and mountains, and the force of the central fires has lifted them to the surface, again to be subjected to the action of the elements, and to pass through the same cycle of changes.



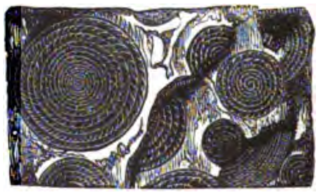
HORIZONTAL STRATA.

7. **Stratified Rocks** comprise nearly all the surface of the land. Many of these formations abound in the fossil[3] remains of plants and animals, and especially in marine forms. Rocks of this kind have therefore received the name of *fossiliferous*[4] *rocks.*

These fossils are sometimes found in so perfect a state that in the remains of a fish not a scale is wanting or out of place; and shells of unknown age have retained not only their shape, but even their brilliant colors. In all parts of the globe these relics are discovered, miles below the general surface of the earth, and also on the tops of the loftiest mountains, proving that the highest peaks were once beneath the ocean.

The amount and extent of these organic remains, microscopic and otherwise, are truly amazing; for each cubic inch of chalk is estimated to contain a million distinct structures.

These organisms form nearly half the bulk of the chalk of Northern Europe, and exceed this ratio in that of Southern Europe; while the unorganized portion of the chalk consists of decomposed shells, which cement the fossils into a compact mass. The beds of crystalline marble in the Pyrenees, and the vast limestone range at the head of the Adriatic Gulf, are composed of fossil shells termed *nummulites*,[5] which are represented in the annexed cut. The nummulitic formation is often thousands of feet in thickness, and is traced from Egypt, through Persia, to the mighty ranges of the Himalayas.



NUMMULITE MARBLE.

One of the richest localities in fossil shells is the *Paris Basin*, a region in the north of France, 180 miles long and 90 miles broad, including within its limits the city of Paris.

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[1] From the Latin word *stratum*, a bed.

[2] From the Greek word *metamorphōsis*, a transformation.

[3] From the Latin word *fossilis*, meaning that which is dug out of the earth.

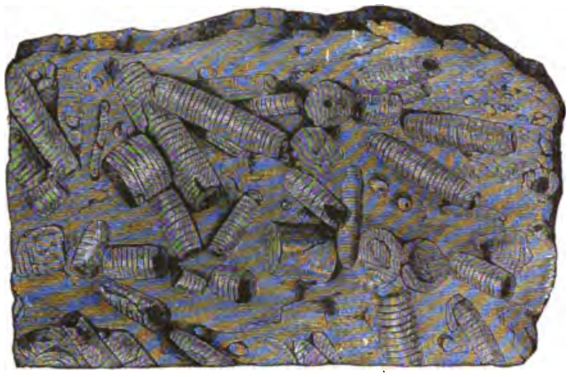
[4] From the Latin words *fossilis*, and *fero*, to bear; *i.e.* fossil-bearing.

[5] So called from the Latin word *nummus*, a coin, and the Greek word *lithos*, a stone; because the fossil resembles a coin in form.

What is said of oxygen, iron, carbon, silicum, and chlorine? 5. How are rocks classified? 6. What are stratified rocks? How are the layers situated? How have these rocks been formed? Mention some of this class. What changes have taken place during the past ages? How are these changes effected? Are they still in progress? 7. What is said of the extent of the stratified rocks? What is said respecting many of these formations? What are fossiliferous rocks? What is said of the perfection and extent of fossils? Give an account of the organisms in chalk. What is said of the thickness and extent of the nummulitic formation? What of the Paris Basin?

Here are vast beds of marl and limestone, so full of minute shells that fifty-eight thousand, on an average, are contained in every cubic inch; and the splendid capital of France is built almost entirely of stones composed of fossil shells.

The central portions of North America consist of fossiliferous strata; and the valley of the Mississippi, and other parts of the United States, abound in rocks filled with corals, crinoids,[1] and shells.



PERFECT COPY OF LIMESTONE, FILLED WITH STEMS OF CRINOIDS, NEAR LOCKPORT, N.Y.

The bones of gigantic animals and reptiles are entombed in the stratified rocks; while, on the other hand, fossil microscopic organisms exist so minute that *forty thousand millions* are contained in a cubic inch of stone, as in the tripoli rock of Bilin in Bohemia. A cubic inch of the marl deposits in Maidstone, Vermont, contains, according to the calculations of Prof. Bailey, 15,625,000,000 distinct structures.

So widely diffused are the fossiliferous rocks that they are supposed to comprise two-thirds of the surface of the present continents.

The study of these rocks is full of interest; for the fossils they enclose reveal to us the former life of our globe. It will be well to remember that the rocks we have been considering are termed *stratified* as regards their *structure, aqueous* as respects their *origin*, and *fossiliferous* in reference to their *composition*.

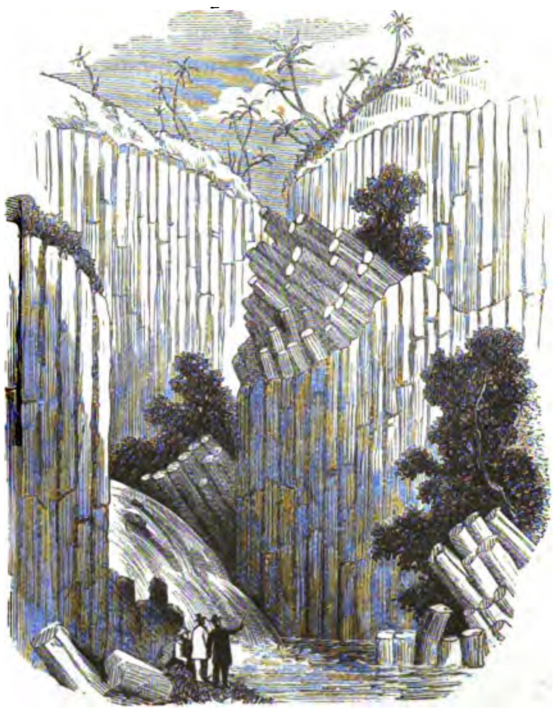
8. **Unstratified Rocks.**—These, as their name implies, are not formed in successive layers, but occur in masses, and are supposed to have been produced by the action of fire: for this reason they are also called *igneous*[2] *rocks*. They are included in three divisions,—viz.: *Plutonic*,[3] *Trap*, and *Volcanic*[4] *Rocks*.

9. **Plutonic Rocks** are those which bear the marks of having first been melted far down in the interior of the earth, then cooled under the immense pressure of overlying rocks, and next upheaved by the expansive force of internal heat. To this class belongs granite,[5] with its varieties syenite and porphyry.

Granite, until recently, was supposed to be the oldest of any of the stratified rocks, but it is now known to have been formed at different eras; for granite veins have been discovered which have forced themselves not only through fossiliferous rocks, but even through masses of other granite, proving that the later granite, in a melted state, must have flowed through the fissures of the stratified rocks and of the older granite. Plutonic rocks have no organic remains.

10. **Trap Rocks** are regarded as the lavas of ancient volcanoes, long since extinct, the molten mass having been cooled beneath water at great depths.

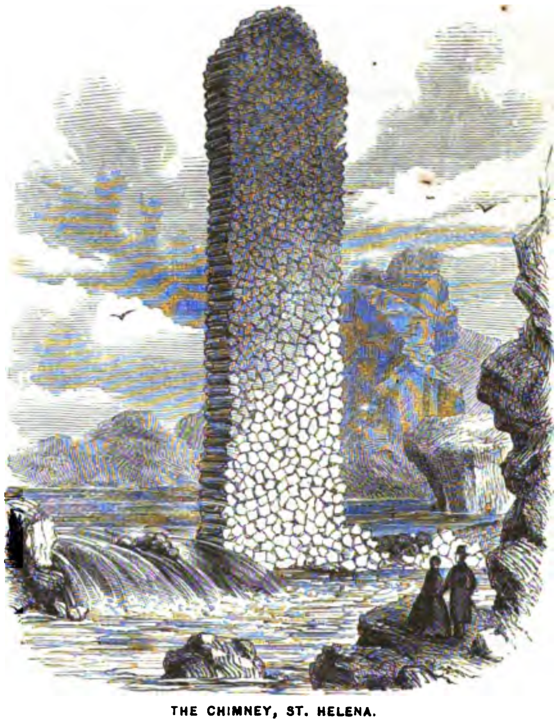
This rock derives its name from the Swedish word *trappa*, a stair, as it often presents the appearance of a series of steps. Its igneous origin is clearly revealed where it breaks through a stratified rock, as a sandstone; for the junction exhibits undoubted evidences of fusion; and in the coal formations the coal, at such places, is reduced to a cinder.



BASALTIC COLUMNS, REGLA, MEXICO.

Trap rock has a tendency to form into columns. Basalt, which is a variety of trap, very hard and compact, and of a dark green hue, displays this peculiarity in a remarkable degree. Ranges of regular basaltic columns are found in different parts of the world. Columbia River flows between precipices of basalt, varying in height from four hundred to one thousand feet, and composed of tiers of pillars, rising one above another, from base to summit.

A fine formation of this kind exists at Regla, in Mexico; and at St. Helena occurs a very curious specimen. A wall of basaltic rock has there been worn away by the sea, except a mass sixty-four feet high, called the "Chimney,"—entirely composed of horizontal prisms of basalt. The Giants' Causeway, in Ireland, and the wondrous Cave of Staffa, reveal, on a magnificent scale, the columnar form of basaltic rocks.



THE CHIMNEY, ST. HELENA.

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[1] So called from the Greek words *krinos*, a lily, and *eidos*, form; because this family of animals, which are nearly extinct, have the shape of a lily with a jointed stem.

[2] From the Latin word *ignis*, fire.

[3] From Pluto, the fabled god of the infernal regions.

[4] From Vulcan, who, according to classic mythology, forged the thunderbolts of Jupiter.

[5] From the Latin word *granum*, grain; because it possesses a granular appearance.

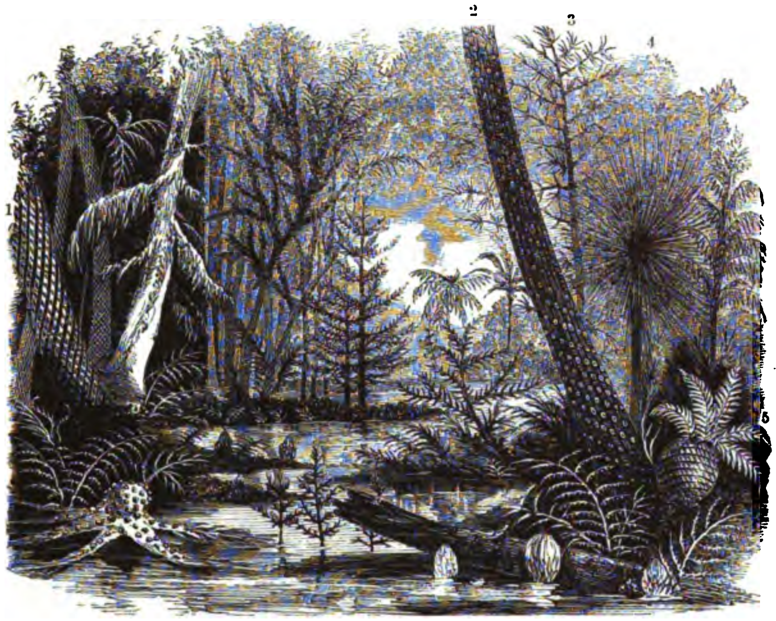
What is said of the building-stone of Paris? Are fossiliferous strata found in North America? What is said of the size of fossils? What is the extent of the fossiliferous rocks? Repeat the classification of the stratified rocks. 8. What are unstratified rocks? How are they subdivided? 9. What is said of the formation of the plutonic rocks? Mention some of the plutonic rocks. Is all granite of the same age? Have these rocks any organic remains? 10. What are trap rocks? Why are they so called? What fact clearly shows the igneous origin of trap? What shape has trap a tendency to take? What variety exhibits this tendency in a striking manner? Give instances of the columnar structure of basalt.

11. **Volcanic Rocks** are the lavas of volcanoes, which appear to have cooled in the air, and under less pressure than the trap rocks. Tufa, obsidian, and pumice-stone belong to this class.

12. **Metamorphic** or **Transformed Rocks** are of *aqueous* origin; but after their formation, having been subjected to intense heat and pressure, they became changed, assuming a crystalline structure, while retaining their primitive arrangement in strata.

Clay has thus been transformed into slate, sandstone into quartz, and limestone into statuary marble. These, with gneiss and mica slate, compose the principal rocks of this group, which constitute a large portion of the surface of the earth. Metallic veins, which are fissures filled with ore, are most frequently found in metamorphic rocks, but are by no means confined to these.

No organic remains are found in rocks of this kind, the intense heat to which they have been subjected having, it is supposed, destroyed every vestige of animal and vegetable life.



FOSSIL FOREST RESTORED. COAL ERA.
1. Lepidodendron. 2. Sigillaria. 3. Araucaria. 4. Pandanus. 5. Zamia.

CHAPTER II.

THE FORMATION OF THE EARTH.

1. From all the researches made by geologists, it appears that the earth was once in a molten state, and was gradually cooled by radiation until the solid crust was formed. This shell, composed, as it is, of materials which are bad conductors of heat, arrested any further escape of the latter, and thus has preserved to the present day the high temperature of the central mass.

But mighty changes have taken place in this primeval crust; for as the rugged ore is subjected to a hundred different processes before it can be fashioned to the various uses which necessity and taste demand, so has it been with the globe. It was designed by the Creator for the abode of man, and destined to be furnished with every appliance, and to be wrought into such forms and combinations as should tend best to perfect his physical, intellectual, and moral nature.

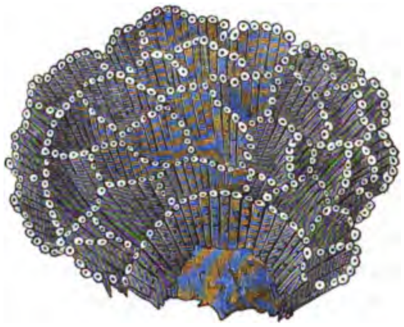
But in its first crude condition the earth was no such habitation; and its present state is the result of changes occurring under the Divine plan, and extending through unknown periods of time. Its surface has been remodelled again and again, mountains have been submerged beneath oceans, and the beds of the latter upheaved into Alpine ranges; and, by these successive transformations, it has gradually been perfected and adapted to its final use.

Amid all these revolutions, the changes in the condition of the earth have been attended with corresponding changes in plants and animals; and their organic remains, imbedded in the rocks, are the records of these transformations. The igneous and metamorphic rocks, destitute as they are of fossils, tell but little of the lapse of time in the construction of the earth; but the aqueous formations, filled with relics of life, unfold the successive chapters of its history before the creation of man.

The fossiliferous rocks are classed under three great divisions, called *Periods*, corresponding with the order of time in which their formations occurred,—viz.: the *Primary*, *Secondary*, and *Tertiary Periods*. These, though subdivided into subordinate groups and systems, possess types of life so obviously unlike as to make three great epochs of creation. To these may be added the *Recent Period*, or that which has elapsed since the creation of man.

2. **Primary Period.**—This is the period of the oldest fossiliferous strata, in which are found corals, crustacea,[1] mollusks,[2] fishes, and a few reptiles. It is distinguished from all other eras by its extraordinary vegetation; for from the Arctic to the Antarctic zone the earth was exceedingly prolific, and trees and plants of rank and luxuriant growth overspread its surface. Lofty forests of pines and araucarias,[3] beautiful tree-like ferns, tall calamites,[4] and graceful palms cast their shadows upon the teeming soil; and, mingled with these, rose the lepidodendron,[5] a gigantic club-moss, and the towering sigillaria,[6] with its fluted trunk; while lowlier plants, of singular form and beauty, spread out their broad leaves to the light.

For untold centuries, forest succeeded forest, and the dense and matted vegetation fell, layer upon layer, on the soil where it had grown, gradually changing into those vast beds of fuel which



FOSSIL CORAL.

11. What is the nature of volcanic rocks? How formed? Mention several rocks which belong to this class. 12. What is the origin of the metamorphic rocks? How have they been transformed? Mention the changes that have occurred. What is said of the extent of the metamorphic rocks? What of metallic veins? Are any organic remains found in these rocks?

What is the subject of the second chapter? 1. What has been proved by the researches of geologists? Why has the earth not continued to cool? For what was the globe designed? Was the earth in its first condition fitted for the abode of man? How has it been perfected? Amid the changes incident to the land, what other changes took place? What constitute the records of these transformations? What formations reveal the first history of the globe? Into what three great periods are the fossiliferous rocks divided, and why? What other period may be added, and what time does it embrace? 2. Describe the primary period. What was produced by the rank vegetation of this period?

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[1] From the Latin word *crusta*, a shell; a class of articulated animals having a shelly covering, as the crab.

[2] From the Latin word *mollis*, soft; animals having soft bodies and no internal skeleton, as the snail.

[3] A kind of pine, only a few species of which now exist, one of which grows in Araucania, in South America.

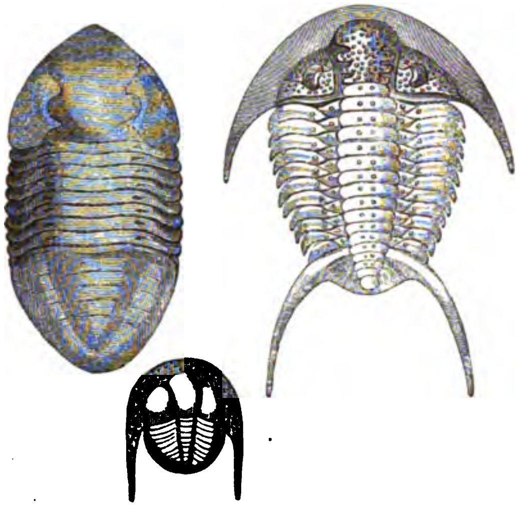
[4] From the Latin word *calamus*, a reed; a family of plants like the rushes and cat-tails of the present day.

[5] So called from the Greek words *lepis*, a scale, and *dendron*, tree; because its stem is covered with diamond-shaped protuberances like scales.

[6] So called from the Latin word *sigilla*, a little image; an extinct family of trees, whose trunks are marked at intervals by scars or figures where the leaves were inserted.

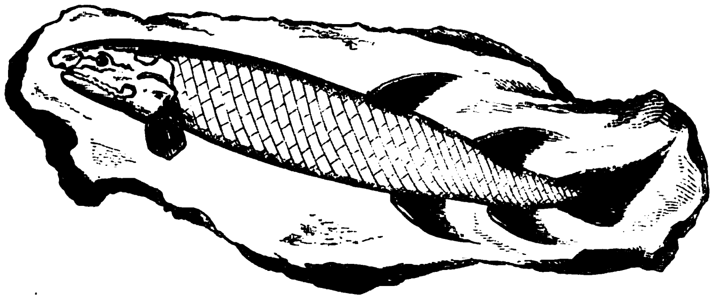
have been treasured up for the use of man. The remains of this primeval life, imbedded in the coal formation, are often extremely interesting and instructive.

Dr. Buckland remarks, in speaking of the coal mines of Bohemia, that the most elaborate imitations of living foliage upon the painted ceilings of the Italian palaces cannot compare with the beauteous profusion of extinct vegetable forms which overhang the galleries of these mines. The roof is covered as with a canopy of gorgeous tapestry, enriched with festoons of graceful foliage, flung in wild, irregular profusion over every portion of its surface. The spectator feels himself transported, as if by enchantment, into the forests of another world, as he beholds trees of forms and character now unknown upon the surface of the earth, existing almost in the vigor and beauty of their primeval life,—their scaly stems, bending branches, and delicate foliage but little impaired by the lapse of countless ages.

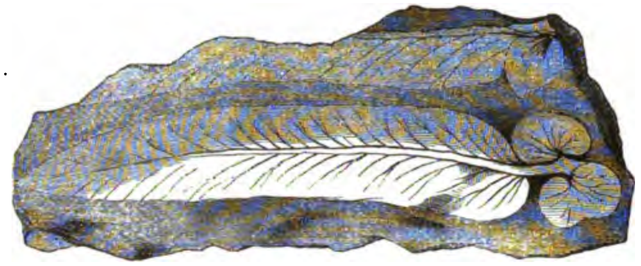

FOSSIL CRUSTACEANS. (Trilobites.)[1]

FOSSIL MOLLUSK.

The succession of fossil forests has been distinctly traced in the carboniferous strata. In the lofty cliffs bordering the Chignecto Channel, a branch of the Bay of Fundy, Sir William Logan discovered *seventeen* tiers of erect fossil trees, at different levels, extending through a formation more than 4500 feet in thickness; and, from the researches of Mr. Richard Brown, at Cape Breton, it appears that no less than *fifty-nine* fossil forests, consisting of lepidodendrons, sigillarias, calamites, and similar kinds, are ranged one above the other, throughout the coal formations of this region.


FOSSIL FISH. (Osteolepis.)

It is the belief of geologists that, at the beginning of this period, the atmosphere was so heavily charged with carbonic acid gas that it was totally unfit for the respiration of animals, while it eminently conduced to the growth of plants, whose food is carbon.


FOSSIL FERNS OF THE COAL ERA.

The rank vegetation of this era, therefore, subserved two ends; for it not only provided vast stores of fuel for the future human race, but, by abstracting from the noxious atmosphere its excess of carbon, the air was rendered pure and healthful, and adapted to the numerous air-breathing animals that were next created.

3. **Secondary Period.**—The marked peculiarity of this epoch is the existence of strange and enormous reptiles of the lizard kind. Such were the *ichthyosaurus*[2] and the *plesiosaurus*,[3]—marine animals that abounded in the seas of this period. The ichthyosaurus, the terror of the waters it inhabited, was a cold-blooded, air-breathing, and carnivorous monster, with the teeth of a crocodile and the head of a lizard. Its jaws were sometimes *six feet* long, and armed with more than two hundred teeth. Skeletons of this extinct race, varying from five to thirty feet in length, are found in great quantities in England, in the valley of the Avon and on the coast of Devonshire. The half-digested remains of fishes and reptiles, found within the skeletons, indicate the nature of their food. The plesiosaurus, which belonged to the same type, was also a marine animal, but not so formidable as the ichthyosaurus. It was remarkable for its long serpent-like neck, which, with the head, equalled, in some species, the length of the body and tail. It moved gracefully over the waters by the aid of paddles at the side.

PLESIOSAURUS DEVOURING A PTERODACTYL. ICHTHYOSAURUS.

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[1] From the Greek words *tris*, three, and *lobos*, a lobe; that is, a three-lobed animal.

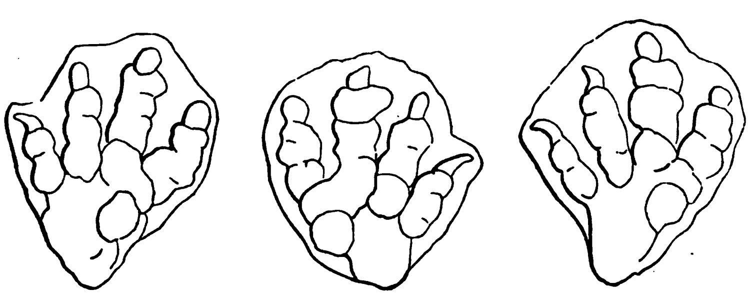
[2] *Fish-lizard.* So called from the Greek words *icthus*, a fish, and *saura*, a lizard.

[3] *Lizard-like.* So called from the Greek words *plesios*, near, and *saura*, a lizard.

What is said by Dr. Buckland respecting the beauty of fossil plants? What is said of fossil forests? Give the instances cited. What is the belief of geologists? What two purposes did the vegetation of this period subserve? 3. What was the peculiarity of the secondary period? Describe the ichthyosaurus and the plesiosaurus. Where are their skeletons found?

4. Contemporary with the marine animals just described were huge land reptiles of the same kind,—such as the *iguanodon* and the *megalosaurus*.[1] The iguanodon, so called from its resemblance to the iguana of the present day, was of great size; for the numerous bones which have been discovered show that it exceeded the elephant in bulk; and, like the latter, it fed upon vegetables. Its proportions were immense; for in one case the circumference of the body was estimated at fourteen and a half feet, and the length of the animal at seventy feet. The megalosaurus was a gigantic lizard, carnivorous in its nature, and is computed to have attained a length of thirty-seven feet, while its body possessed the enormous girth of twenty-two and a half feet.

But the most extraordinary creature of this period was the *pterodactyl*,[2] which somewhat resembled a bat, and yet was allied to the lizard. Its wings, when extended, measured four feet from tip to tip, and from these projected fingers, armed with long hooks. Most of these animals had the nose elongated, like the snout of a crocodile, and possessed conical teeth. The eyes of the pterodactyls were of enormous size, enabling them to fly by night. They had, probably, the power of swimming.



BIRD-TRACKS IN THE SANDSTONE OF THE CONNECTICUT VALLEY.
Length of track, 20 inches. Breadth of track, 15 inches.

During this epoch colossal birds stalked over the earth, whose tracks, from eighteen to twenty inches long, impressed upon the rocks, remain to the present time.

It may be asked, How can the preceding statements be proved? The answer is as follows:—

The bones of these animals, sometimes forming entire skeletons, are found entombed in the rocks of this period; and to such perfection has the science of comparative anatomy attained, that an accomplished naturalist is able from a skeleton, or even from a few bones, to determine with accuracy the nature, habits, and size of races of animals long since extinct, and to delineate their forms as if they were living.

Such, then, were some of the strange beings which existed during the secondary period, all perfectly adapted to the condition of the globe as it then was. For ages they subserved the ends of their creation, and then perished, their fossil skeletons and footprints alone remaining to tell that they ever existed,—the hieroglyphics of the rocks, by which the early history of the world is unfolded.

5. **Tertiary Period.**—The tertiary period seems to be marked by the beginning of a new system of phenomena, very similar to those now in progress on the surface of the globe. The rocks and other formations are, to a great extent, like those which continue to be formed at the present day by the deposits of seas, rivers, and lakes; and the remains of animal and vegetable life approach nearer to the species now existing than the relics of the preceding ages.

The Saurian reptiles have passed away, and the beasts of the field, vast in size and countless in number, swarm over the earth. "Its mammoths and mastodons," says Hugh Miller, "its hippopotami, its rhinoceri, its enormous deinotherium and colossal megatherium, greatly more than equalled in bulk the largest mammals[3] of the present time, and far exceeded them in number."

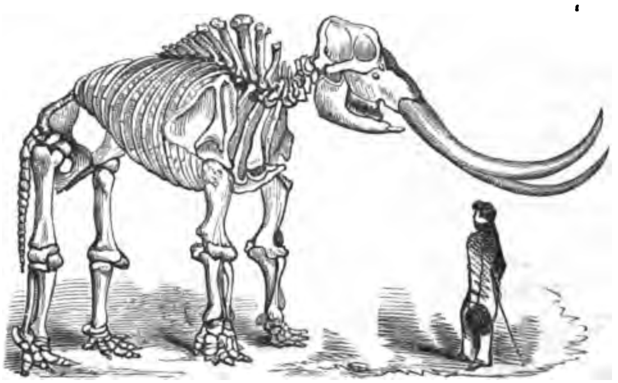
The remains of the *mammoth*, or fossil elephant, are found all over Europe and North America, imbedded in the frozen gravel, as far north as the seventy-second degree of latitude. In Siberia these relics have been discovered in such quantities that the deposits are termed *ivory quarries*, and thousands of tusks, some of which weigh nearly five hundred pounds, are annually collected for sale. It has been supposed that in Siberia alone the remains of a greater number of elephants have been found than now exist throughout the world.

Not only have the well-preserved bones and tusks of these huge animals been brought to light, but, in one case, an entire body has been discovered, with the flesh and skin as fresh as if it had been recently entombed.

In the year 1799 a fisherman observed in a cliff of ice and gravel, on the banks of the river Lena, a shapeless mass, which, as the ice thawed away, eventually proved to be the complete body of a mammoth. It was twelve feet high, and about sixteen feet long, while its curved tusks were nine feet in length. The body was in such a state of preservation that dogs and wolves preyed upon the flesh. The skin was covered with coarse hair, fifteen inches long.

Allied to the mammoth was the *mastodon*,[4] whose bones are widely scattered throughout the world.

The most perfect skeleton of the mastodon ever found in this country is now in the possession of Dr. John C. Warren, of Boston. It was discovered in the year 1845, at Newburg, N.Y., in a peat bog, standing erect, the animal having probably been mired and lost its life while in search of food. The height of the skeleton is eleven feet, its length, exclusive of the tail, seventeen feet; the tail is six feet long, and the length of each of the tusks is nearly eleven feet.



SKELETON OF THE MASTODON.

6. The *megatherium*[5] was another mighty quadruped of strange

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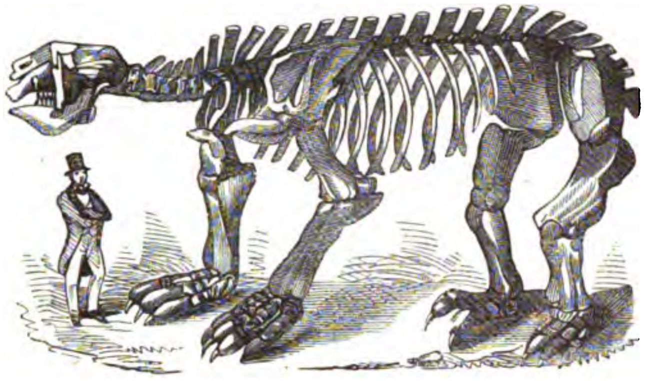
[1] So called from the Greek words *megalos*, great, and *saura*, a lizard.
[2] So called from the Greek words *pteron*, wing, and *dactulos*, finger.
[3] From the Latin word *mamma*, breast; animals that suckle their young.
[4] So called from the Greek words *mastos*, nipple, and *odous*, tooth; an animal allied to the elephant, but having nipple-shaped or conical projections on its teeth, which are not found on those of the elephant.
[5] So called from the Greek words *megas*, great, and *thērion*, a wild beast.

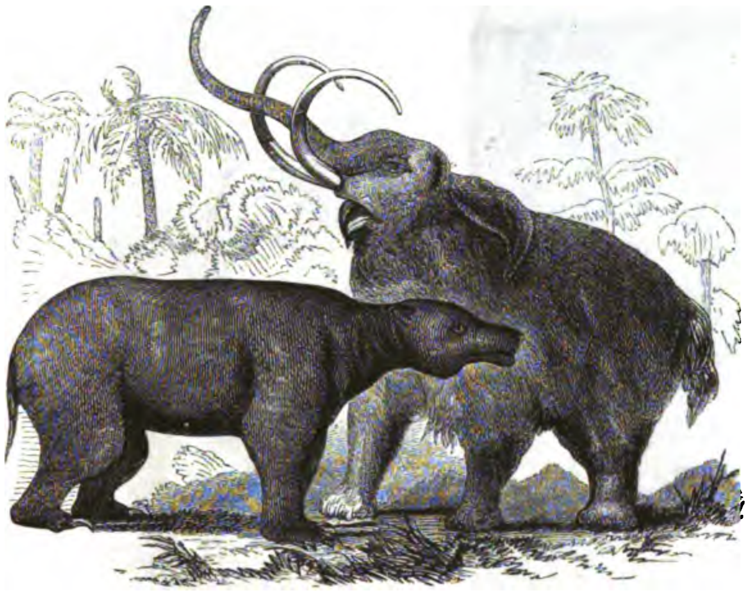
4. What other animals now existed? Describe them. Give an account of the pterodactyl. What is said of the birds of this era? How can the nature, habits, size, and forms of extinct races of animals be determined? What is said respecting the animals of the secondary period? 5. What is the peculiarity of the tertiary period? What kind of animals existed during this period? What is said of their number? What is the remark of Hugh Miller? What is said respecting the extent of the remains of the mammoth? What was discovered on the banks of the Lena? What other huge animal now existed? Why so called? Describe the skeleton mentioned. 6. Describe the megatherium.

construction. Its head and neck were like those of the sloth, and its feet were armed with claws of enormous length. It was an unwieldy animal, possessed of vast strength, and admirably formed for tearing up the ground in search of roots for food, and for wrenching off the branches of trees upon the twigs and the foliage of which it fed.

This gigantic animal attained a length of eighteen feet, and measured around its body fourteen and a half feet. A skeleton of the megatherium was found, towards the close of the last century, in a bed of clay one hundred feet below the surface, on the banks of the river Luxan, twelve miles from Buenos Ayres, in South America. It was figured and described by Cuvier, who assigned to this extinct animal the name it now bears.



SKELETON OF THE MEGATHERIUM.



MEGATHERIUM. (Restored.) MAMMOTH.

The *mylodon*[1] and the *deinotherium*[2] were two other colossal creatures of the tertiary period. The former reached the length of thirteen feet, and was nearly as large as the hippopotamus. It fed on plants, and probably browsed on shrubs and branches, breaking down the latter with its strong forearms, which were furnished with powerful claws. The latter was a huge mammal, eighteen feet in length, and, like the mylodon, was herbivorous. It is supposed to have lived principally in the water, and is remarkable for possessing two enormous tusks, curving downwards, which it probably used for tearing up the roots of aquatic plants.

7. **Recent Period.**—At the beginning of this era the land, which during the preceding ages had been repeatedly reconstructed, is supposed to have assumed its present configuration. But it was destitute of life; for the old forms of organic existence had perished. The earth was now to be clothed again with innumerable species of fresh plants, and to be filled with new races of animals before the advent of man. The mighty changes which had occurred during the untold ages of the past were but preparations for our own period, and had at length transformed the crude planet into a dwelling-place for the human race. Beneath its surface immense and priceless treasures were now accumulated, amply sufficient for all the demands of man in his onward march of civilization.

There lay coal-fields of almost fabulous extent, and rich, metallic deposits, without which the physical progress of the world would have been impossible, and commerce and the arts unknown. There, too, were vast rocky strata, destined to be again uplifted, and to rise as stately cities and in the countless enduring structures which necessity and taste require.

On the surface the finer portions of the rocks which had been worn away by the waters, ground by the ice and glaciers, and disintegrated by the frost and heat, were now spread out in fertile valleys and plains, and smoothed the rugged slopes of the mountain-ranges.

No soil is productive that consists of a single material. Vegetation cannot thrive in pure clay, chalk, or sand; but a mixture of these, united with a portion of decomposed animal and vegetable matter, forms a soil of excellent quality.

The former convulsions of the earth had greatly contributed to its productive power; for the upheaval and sinking of the rocky strata into their varied positions had caused such a union of the different elements of fertility as could not have resulted had the globe been encased in a rock of a single kind.

As time advanced, the fall of the foliage, the decay of forests, and the death of successive races of animals tended continually to enrich the soil; while over land and sea rested a pure and salubrious atmosphere, ministering to the wants of every form of life.

At length the era of mind and soul began. MAN arose, created in the image of his Maker, and was invested with the dominion of the globe, thus perfected for his use. It was not a mere accumulation of matter without order or design; but an exquisitely organized structure, filled with a most intricate mechanism, in which the countless parts worked together with the utmost precision and harmony to elaborate and produce throughout all time that endless variety of beneficent results which God in his wisdom and goodness had from eternity ordained.

8. **Changes in Progress.**—Within the recent period important geological changes have occurred, and are still in progress. The sea in some places has encroached upon the land, and in others the land upon the sea: so that the waves now sweep over the sites of ancient cities, and bays and arms of the sea have been transformed into solid land. In 1399, Henry of Lancaster, afterwards Henry IV., landed with his adherents at Ravenspur, on the coast of Yorkshire. This was an ancient seaport, which once rivalled Hull in commer-

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[1] Derived from the Greek words *mulē*, a mill, and *odous*, a tooth, as the teeth of the animal consisted of a few broad grinders.

[2] So termed from the Greek words, *deinos*, terrible, and *thērion*, a wild beast.

Where has a skeleton of this animal been found? Describe the mylodon and the deinotherium. 7. What period is next in order? Describe it. What effects had been wrought by the preceding changes? What preparations had been made for the human race? What is essential to render a soil productive? What has been the effect of the transformation to which the earth has been subjected? What was the condition of the globe when man was created? Is the earth a mere accumulation of matter? 8. Describe the changes in progress. Give instances of the advance of the ocean, and of the land.

cial advantages; yet nothing of it now remains but banks of sand, which are covered by the flood-tide. The Goodwin Sands, so dangerous to mariners, constituted, in the eleventh century, an extensive lordship, belonging to the powerful Earl Godwin.

On the other hand, the place where Julius Cæsar landed when he invaded Britain is now far inland; and Ostia, which in the time of the Romans was the port of the Tiber, is now *three miles* from the water. The great rivers of the globe, such as the Mississippi, the Amazon, the Ganges, and the Nile, are also constantly carrying down to the coast immense quantities of earth, and cause the land to gain upon the sea.

Fire, as well as water, has likewise been at work within this era, and still continues its action. For not only do the annals of the past tell of the elevation and subsidence of the earth's surface, during the progress of earthquakes and the eruptions of volcanoes, but in the present century the same phenomena have occurred, as will be shown in a subsequent chapter.

A more wonderful, though less striking, display of its action is seen in the slow elevation or depression of different countries.

The coast of Sweden and Finland is gradually rising, as proved by the marks established by the Swedish government, the line of elevation extending, north and south, for a thousand miles. According to Lyell, the rise at Uddevalla is about four feet in a century, and greater farther north.

In Greenland the land, for a length of six hundred miles, has been slowly sinking during the last four centuries; for islands have been submerged, and old buildings that formerly stood upon the shore are now beneath the waves. These changes are supposed to be due to the cooling and consequent contraction of the interior molten matter,—the crust of the earth rising in some places and sinking in others, in order to adapt itself to the form of the contracted central mass.

In this period, as in all those that preceded it, we recognize the existence of two opposing agencies,—fire and water. The action of the latter tends to reduce the surface of the earth to a dreary level; that of the former breaks up the monotony of the plain, and gives the earth its pleasing diversity of mountains and valleys, hills and dales.

State changes that have been caused by fire. Give the facts illustrating the elevation and sinking of the land. During the formation of the globe, and at the present day, what two mighty agencies have been, and still are, at work? What is the effect of their action?

NATURAL TUNNELLED TOWER, MT. SOLON, VA.

GROTTO DES DEMOISELLES.—HERAULT.

NATURAL BRIDGE, VIRGINIA.

PART THIRD.

LAND.

1. The surface of the globe is estimated to contain 197,000,000 square miles, and is comprised under the two grand divisions of *land* and *water*.

The land occupies only about a fourth of the surface; for its extent is computed at 50,000,000 square miles. It is also very unequally distributed; for, while the southern hemisphere contains but 13,000,000 square miles of land, the northern has 37,000,000 square miles, or nearly three times as much. A similar inequality will be found to exist, and nearly to the same extent, if we divide the globe into eastern and western hemispheres by a meridian 20° west of Greenwich.

2. This subject is comprehended under the following divisions,—to wit: *Continents*, *Islands*, *Mountains*, *Valleys* and *Passes*, *Table-Lands*, *Volcanoes*, *Earthquakes*, *Caverns and Natural Arches*, and *Mineral Productions*.

What is the subject of Part Third? 1. What is the area of the globe? Under what two grand divisions is the surface comprised? What is the ratio of the land to the water? What is the extent of the water? Is the land equally distributed? 2. How is this subject divided?

CHAPTER I.

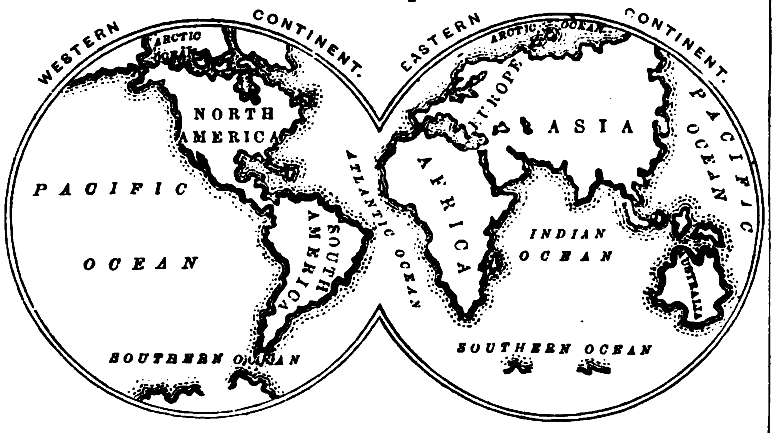
CONTINENTS.

3. **The Land,** in regard to its configuration, is presented under two aspects,—namely: its *horizontal outline* and its *relief* or *vertical elevation.* The first relates to continents and islands; the second, to mountains, table-lands, and plains.

4. **Continents.**—Continents are vast, unbroken masses of land. Of these there are two: the *Eastern,* embracing Europe, Asia, and Africa; and the *Western,* which includes North and South America. Australia, from its great size, has sometimes been termed a continent; but it is more properly classed among islands. Greenland may possibly be a part of an Arctic continent, extending around the north pole.

Since the year 1819, various portions of land have been discovered near the Antarctic circle by American, English, French, and Russian explorers, which have been regarded as the northern points of an Antarctic continent; but the question of their connection is not yet settled.

The largest known mass of land in this region was discovered on the 16th of January, 1840, by the United States Exploring Expedition, under Captain Wilkes, stretching east and west through a distance of 1700 miles. Victoria Land, the next in size, was first seen by Captain J. C. Ross, on the 11th of January, 1841. The most southerly point attained by this daring navigator was situated in 79° S. lat., only 11° from the south pole.



5. **Eastern Continent.**—The Eastern Continent extends through more than two hundred degrees of longitude, from Cape Verd, the most westerly point of Africa, in 17° 33′ west longitude, to East Cape, the eastern extremity of Asia, in 170° west longitude, or 190° east longitude. It comprises one hundred and thirteen degrees of latitude, from Cape Cevero Vostochnoi, in Siberia, in 78° 16′ north latitude, to Cape Agulhas, the most southerly point of Africa, in 34° 50′ south latitude.

The area of the Eastern Continent, with its islands, is about 30,000,000 square miles. Its greatest depression is at the Dead Sea, the surface of whose waters in the summer is twelve hundred and ninety-eight feet below the level of the Mediterranean, from which it is separated by a belt of land fifty miles broad. In Central Asia the land rises to the highest elevation on the globe; where, towering above the stupendous chain of the Himalayas, Mount Everest lifts its snowy head to the height of twenty-nine thousand one hundred feet above the ocean level.

The three great divisions of the Eastern Continent differ materially in size. Europe is the smallest, and contains about 3,765,000 square miles. Africa is nearly three times larger, having an area of 10,936,000 square miles; while Asia, whose superficial extent is 15,196,000 square miles, is nearly five times greater.

VILLAGE IN THE HIMALAYAS.

Europe and Asia resemble each other in several important physical features: both are filled with rich and fertile regions, and traversed by vast mountain-ranges and great river-systems; while deep gulfs and bays pierce far into their coasts.

In Africa, on the contrary, a large portion of the surface consists of sterile and sandy deserts; while an elevated plain occupies the interior of South Central Africa, and is watered by the streams that flow inland from the enclosing mountains. Its coastline is almost unbroken, and but few rivers present facilities for internal communication.

6. **Western Continent.**—The Western Continent extends from Cape St. Roque, in 35° west longitude, to Cape Prince of Wales, in 168° west longitude,—a distance of one hundred and thirty-three degrees of longitude. In latitude it stretches from Point Barrow, in 72° north latitude, to the Strait of Magellan, in 54° south latitude. Its surface is computed at 14,595,000 square miles; and it is, therefore, only about half the size of the Eastern Continent.

STRAIT OF MAGELLAN.

What is the subject of Chapter I.? 3. Under what two aspects is the configuration of the land presented? What does the first relate to? What the second? 4. Define the term continent. How many continents are there? What regions do they comprise? What is said of Australia and Greenland? Is there an Antarctic continent? Give the facts on this point. How far south did Captain Ross proceed? 5. Describe the Eastern Continent in detail. Compare the divisions of this continent in respect to size. What is said of Europe and Asia? What of Africa? 6. Describe the Western Continent.

The highest point of land on this continent is the peak of Aconcagua, in Chili, which rises to the height of twenty-three thousand one hundred feet above the sea, but is still six thousand feet below the summit of Mount Everest. Depressions below the general surface occur, as in Dead Man's Valley, in California, which is one hundred feet below the sea-level.

Of the two divisions of this continent, North America is the larger, embracing about 8,043,000 square miles: the area of South America is computed at 6,552,000 square miles.

7. **Coast-lines.**—By the term coast-line is understood the boundary line between the land and the sea. The greater the extent of coastline which any country possesses, in comparison with its area, the more deeply must it be penetrated by gulfs, bays, and arms of the sea. These physical features are of great importance, since they affect not only its climate and productions, but also increase its facilities for commerce, by furnishing numerous ports and roadsteads, and thus most essentially contribute to its power, wealth, and influence.

The six grand divisions of the globe differ greatly in this respect. Europe and North America, leading in the march of civilization, stand first. Australia, South America, and Asia come next. Africa is the last. The following table exhibits, according to Ansted, the approximate ratio of the number of square miles to one mile of coast, in each of these divisions:—

SQUARE MILES TO ONE MILE OF COAST.

Europe	187	Australia	340
North America	266	Asia	528
South America	440	Africa	738

Not only is a wise and beneficent provision revealed in the indented shores and irregular boundaries of the continents, but also in the form and structure of the coasts themselves. Every one might have consisted, throughout its entire length, of dangerous and precipitous cliffs, with scarcely a bay or harbor, thus preventing commercial enterprise and intercourse with other parts of the world. Such rocky barriers exist in Norway, and on the iron-bound coast of Patagonia, but they are exceptions; and in their place we find low and shelving shores, affording easy access from the land to the ocean.

8. **Form and Elevation of the Continents.**—A glance at a map of the world reveals the fact that the great continental masses tend to assume a *peninsular* form towards the south. Thus, South America ends in the bold promontory of Cape Horn, and Africa with the Cape of Good Hope, crowned with the Table Mountain. North America grows narrower as it advances southward, till a mere strip of land separates it at Panama from the Atlantic and Pacific Oceans. Greenland terminates to the south with Cape Farewell, and India with Cape Comorin. Malacca, Arabia, Greece, Italy, and Spain exhibit in the same directions the peninsular figure, the latter country ending in the rock-fortress of Gibraltar.

The mean elevation of the continents depends, according to Humboldt, not so much upon their mountain-ranges as upon the extent and heights of their plains and table-lands. On the supposition that the mountains of the world were spread over the subjacent lands, the following estimate has been made. The levelled mountains of Europe would raise its surface but six hundred and seventy feet above the sea-level; those of North America, seven hundred and fifty feet; South America would thus be elevated eleven hundred and thirty feet; and Asia, eleven hundred and fifty feet. The average elevation of the two continents, omitting Africa, would be only nine hundred and twenty-five feet. The mean elevation of Africa would probably be sixteen hundred feet, and that of Australia, possibly, five hundred feet.

GIBRALTAR.

9. **Resemblances and Contrasts.**—The two continents correspond in certain particulars, but are strikingly dissimilar in others. The Eastern is almost divided across, from east to west, by extended seas,—the narrow isthmus of Suez alone connecting Africa with Asia. On the Western the waters have made a like encroachment,—the Atlantic Ocean forming westward an immense bay, and almost separating North America from South America.

Both likewise extend, in broad masses of land, to about the same latitude north, and both terminate, towards the south, in vast triangular-shaped regions,—to wit: South America in the Western Continent, and South Africa in the Eastern.

Each has also its great cluster of islands,—the West Indian isles being the counterpart of the Eastern Archipelago; and the fiords, or rock-bound inlets, of Norway are repeated in the ocean chasms that pierce the cliffs of the Patagonian coast.

On the other hand, marked differences exist between the continents. In the Western the general direction of the land is nearly at right angles to that of the Eastern; for while in the former the greatest line of length stretches from southeast to northwest, in the latter it extends from southwest to northeast. The chief mountain-ranges of the continents follow also similar courses.

If we contrast the three great northern divisions of the two hemispheres with the two southern, striking diversities are likewise perceived. The former far exceed the latter in size, and, owing to their mutual proximity, analogous climates, and facility of intercommunication, possess a physical unity which South America and Africa do not enjoy.

It is also worthy of remark that the extent of the temperate regions, which are so peculiarly adapted to the full development of man, is far greater in the northern than in the southern zone.

These facts are not to be overlooked when we seek for the causes why the dominant races of the earth have ever been found within the three northern grand divisions.

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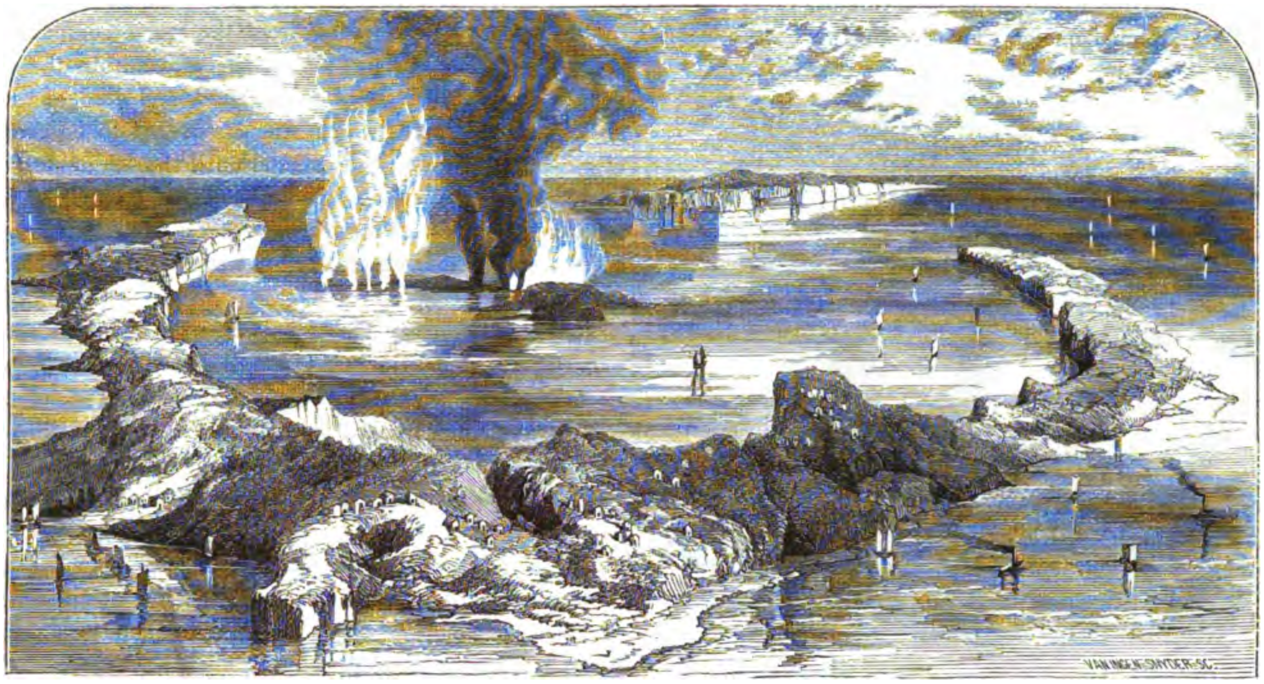
7. What is understood by the term coast-line? How is the coast-line of a country connected with its commercial advantages and prosperity? What is said respecting the extent of coast-line in the six grand divisions of the land? Give the table. What beneficent provision is here seen? What is the general rule in regard to the structure of coasts? 8. What is said of the form and elevation of the continents? What of the elevation of Australia? 9. Describe the resemblances and contrasts which exist between the continents. What is said respecting the extent of the temperate regions in northern latitudes?


VAN INGEN-SNYDER SC.

VOLCANIC ISLAND OF SANTORINI.

CHAPTER II.

ISLANDS.

1. **Islands** comprise the remainder of the land, containing together nearly one-fifth of its entire surface, or about 10,000,000 square miles. They are classified according to their *situation* into *Continental* and *Oceanic*, and in respect to their origin into *Volcanic* and *Coral islands.*

2. **Continental.**—These islands, which are long in proportion to their breadth, are found skirting the shores of continents, running parallel to the maritime mountain-ranges, and usually possess the same structure.

They appear to be portions of such ranges whose submarine vales have either been overflowed by the ocean, or never yet raised above its waves. Such is the chain of islands extending from the North Cape along the whole coast of Norway, and prolonged to Great Britain, through the Faroe, Orkney, Shetland, and Western Isles. To this class belong also the West Indian Archipelago, and the vast chain of islands on the eastern coast of Asia, extending from Kamtschatka to Formosa, with many others which a glance at the map reveals.

England, it is supposed, was once connected with the mainland of Europe, but was afterwards separated by an irruption of the sea, which formed the Straits of Dover. To a similar cause is attributed the existence of the West Indies, and of the Archipelago of India.

3. **Oceanic Islands.**—These, as their name implies, lie in mid-ocean, and form extended groups, which are regarded as the summits of submarine mountain-ranges. They are mostly found in the Pacific, which contains nearly seven hundred, and stretch away in a mighty chain from the coast of Asia, in a southeasterly direction, as far as Easter Island and Sala-y-Gomez, a distance of eight thousand miles. A few are scattered throughout the Atlantic and Indian Oceans.

4. **Volcanic Islands.**—Numerous islands exist in the ocean which are evidently the product of volcanoes. In some the fiery element is still active, and eruptions not unfrequently happen; while in the rest the geological features prove unmistakably their volcanic origin. The volcanic islands extend from Jan Mayen, in 72° north latitude, to the Antarctic lands, occurring chiefly in the Pacific and Indian Oceans, and forming three great belts, each thousands of miles in length.

The *first* begins with the Banda group of islands, and extends through the Sunda group of Timor, Sumbawa, Bali, Java, and Sumatra, and the Nicobar and Andaman Isles, into the Bay of Bengal, —a distance of more than twenty-five hundred miles.

The *second* commences north of New Guinea, and, sweeping in a curve to the south, embraces New Britain, New Ireland, Solomon's Archipelago, the New Hebrides, and New Caledonia.

The *third*, and most important, begins at Gilolo, one of the Molucca group, and, passing northward, comprises the Philippine Isles, Formosa, and the Loo-Choo group, and, proceeding through the Japan Archipelago and the Kurile Islands, ends at the peninsula of Kamtschatka.

In the Atlantic Ocean, the Azores, and the Madeira, Canary, and Cape Verd Islands, are all of volcanic origin.

5. In numerous islands of this class active volcanoes exist; in others all commotion appears to have ceased, though the evidences of igneous action are still apparent. In Fayal, one of the Azores, the undulations of the lava, before it hardened into rock, are still seen upon the cliffs that face the ocean.

Barren Island, in the Bay of Bengal, belonging to the Andaman group, is one of the most remarkable volcanic islands now active. From the centre of the island rises a cone, eighteen hundred and

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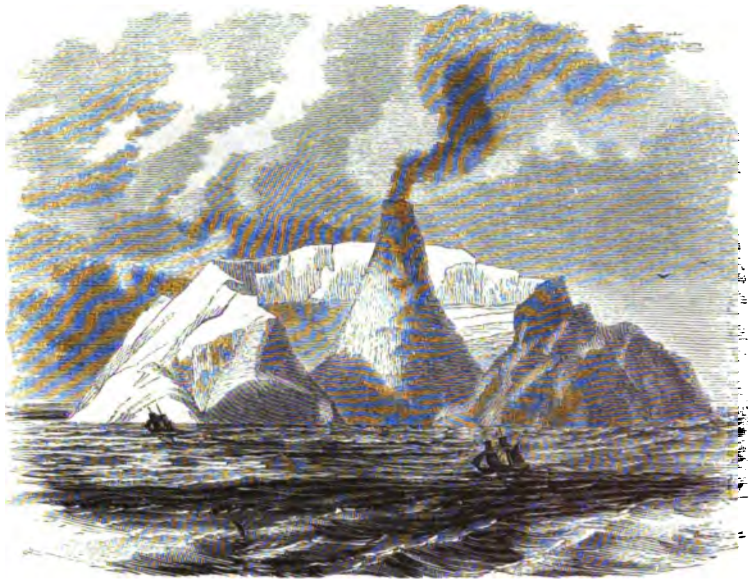
What is the subject of Chapter II.? 1. How much of the land do islands comprise? How are they classified? 2. What is said of continental islands? Give instances. What is said respecting England, the West Indies, and the Archipelago of India? 3. What are oceanic islands? How are they arranged? What are they supposed to be? Where are they principally found? How many does this ocean contain? What great chain is mentioned? Are there many of these islands in the other great oceans? 4. What is said of volcanic islands? What of their extent? Where do they chiefly occur? Describe the three most remarkable ranges. What volcanic islands are found in the Atlantic Ocean? 5. What is said respecting the volcanic action that has produced these islands?

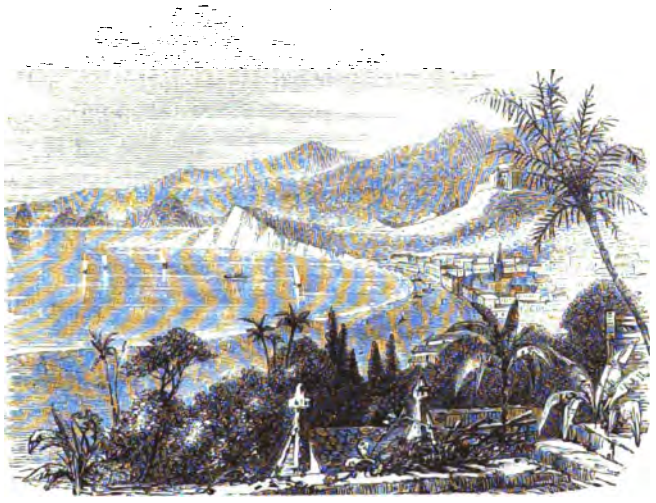
forty-eight feet high, from which issue vast volumes of smoke and showers of red-hot stones, some of which weigh two or three tons.



BARREN ISLAND.
(Volcanic island: active.)

Only on the outer edges of the island does vegetation exist, but scant and dwarfed, and frequently blasted by the hot and fiery eruptions from the central cone, which is surrounded by a volcanic wall of nearly its own height. The island is about twenty miles in circumference, and at a quarter of a mile from the shore no bottom is found at the depth of one hundred and fifty fathoms.

The beautiful island of Madeira is one of many others in which all volcanic action seems to have ceased.



MADEIRA.
(Volcanic island: extinct.)

6. But the mighty internal forces that have raised these islands from the deep are still at work; and there are well-attested instances of new islands being formed by volcanic agency. In the group of the Azores new islands have successively appeared in the years 1628, 1720, and 1811. The most remarkable of these occurrences is that which took place in the last-mentioned year, about a mile west of the western extremity of St. Michael.

The formation of the island was preceded by severe earthquake-shocks, and, before they ceased, a dense column of smoke was seen, on the 13th of June, rising from the sea, accompanied with loud explosions and flashes of lightning; and within the column were beheld large quantities of ashes, sand, and cinders. Soon after, a dark mass appeared, which was discovered to be the upper edge of a rock. It gradually increased until the 4th of July of the same year, when it had attained its greatest size, forming an island a mile in circumference and three hundred feet in height, having a crater[1] in the centre, from which boiling water was constantly flowing into the sea.

This extraordinary spectacle was witnessed by Captain Tillard, who called the island Sabrina, from the name of the vessel under his command. In the following October the island began to diminish, and a few months later its site was occupied by nothing but a reef, which was covered by the waves at high tide. In 1823 the depth of the sea at this spot was sixty fathoms, being twice as deep as it was before the island arose.

The island which appeared in 1720 was attended by the same phenomena as those which accompanied the one just described. It reached the height of three hundred feet, and retained its size for two years, after which it gradually disappeared.

On the Icelandic coast a volcanic island called Nyöe, or New Island, emerged from the sea in 1783, opposite Cape Reikianaes; but in a short time it sunk, and was again covered by the waves.

In July, 1831, an island which received the name of Hotham, or Graham Island, was erupted from the sea, between the town of Sciacca, in Sicily, and the island of Pantellaria. It attained an elevation of two hundred feet, and was about a mile and a quarter in circumference. Before the close of the year it disappeared, and fifteen years afterwards the sea was more than two hundred feet deep at this spot.

The new volcanic islands above described have been but temporary formations; but such a condition is not necessarily a characteristic of this phenomenon. Thus, the Aleutian group presents instances of recently-formed islands which appear to be permanent. Such are the two which were added to this group in 1806 and 1814.

The first of these was ten years in forming, appearing in 1796 and gradually increasing until 1806. In the latter year it was visited by some scientific explorers, the soil, before that time, being too hot to tread upon. It took six hours to sail around the island, and five to walk to its summit. The second island, after reaching an altitude of three thousand feet, sunk a little; but both have since remained unchanged.

The most remarkable instances of the kind have occurred in the Bay of Santorini, in the Grecian Archipelago. The island of Santorini, one of the Cyclades, is in the shape of a horseshoe, and encloses an oval bay, about seven miles long and five miles broad, within which are situated four islands that have arisen within the period of history,—the last as late as the year 1866.

The first of these, called Palaia Kameni, was erupted about two centuries before the Christian era. The second, Mikra Kameni, emerged from the sea in 1573, and rises in the midst of the bay to the height of one hundred feet. A much larger island, named Nea Kameni, was formed about the middle of the year 1707.

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[1] From the Greek word *kratēr*, a bowl; the circular cavity at the summit of a volcano.

Describe Barren Island. What is said of Madeira? 6. Have volcanic islands ever been seen in the process of formation? Describe the phenomena attending the eruption of the island of Sabrina. What is said of the island which arose in 1720?

What other islands are mentioned? Have these been permanent formations? Have all newly-formed volcanic islands necessarily a temporary existence? Describe the new islands of the Aleutian group.

It appeared at a spot where the water had previously been from five hundred to six hundred feet deep, and attained a general elevation of from twenty to thirty feet, with a circumference of nearly two miles; and at length a conical mountain arose, three hundred feet high, crowned with a crater. The formation of the island was accompanied with an earthquake and loud subterraneous noises, while smoke, flames, and vapors issued from the sea and the uprising land.

On the 31st of January, 1866, according to the Greek correspondent of the London Times, a noise, like volleys of artillery, was heard at Santorini, but without any earthquake. On the following day, flames appeared above the sea in a part of the bay called Vulcanos, rising to the height of fifteen feet, and were also seen streaming at intervals from the southwestern portion of Nea Kameni.

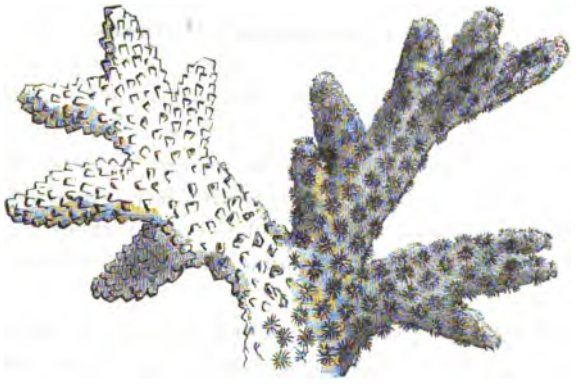
This island was rent by a deep fissure, and in the southern part sunk considerably. On the 4th of February the eruptions became more violent, and the new island was visible next morning, increasing sensibly to the eye as it rose out of the sea at a short distance to the south from Nea Kameni. Within five days it attained a height of from one hundred and thirty to one hundred and fifty feet, having a length of three hundred feet and a breadth of one hundred feet.

The bottom of the bay around Nea Kameni was greatly elevated during the eruptions, the depth of the sea in one place being only one hundred and eighty feet where it was formerly six hundred feet. The temperature of the sea rose from 62° Fah. to 122° Fah. at points as near to the seat of volcanic action as it was safe to approach. The formation of this island is illustrated by the cut at the head of this chapter.

7. **Coral Islands and Formations.**—These wonderful structures are the work of small marine animals belonging to the class of the polyps which exist in countless multitudes in the Indian and Pacific Oceans and the tropical seas, and which live together in communities of vast extent.

The coral is an aggregation of stony cells, composed of carbonate of lime, and secreted by the animals that envelope it from their food and from the waters of the ocean, being formed like bones in the higher orders of animals.

The coral rock consists of the united skeletons of dead polyps. Once elevated above the surface of the sea, and subjected to the action of the elements, the rock becomes disintegrated, while seeds and plants are borne thither by the winds and currents; and soon, beneath the power of a tropical sun, vegetation clothes the naked surface, and the stately palm rises with its graceful foliage.



(Dead.) CORAL. (Alive.)

A wondrous variety of form prevails in the coral structures; for there is hardly any type of vegetation, whether trunk, branch, leaf, or flower, which is not copied by the coral animals.

These formations occupy a belt of the ocean limited north and south by the isothermal lines of 70° Fah.

The coral animal always builds perpendicularly upwards. It cannot exist above the surface of the water, nor at a greater depth than from one hundred and fifty to one hundred and eighty feet. Yet the coral rock extends far below this limit; for, at the distance of but a few hundred feet from the shores of coral islands, no bottom has been found at the depth of four hundred fathoms.

This last fact is explained by Mr. Darwin upon the theory that the bed of the ocean upon which the coral insects began, at first, to build has gradually sunk, while they continued, as fast as it subsided, to work upward to the surface of the water. The existence of coral above the sea-level is attributed, in the case of islands, to volcanic agency; but the vast blocks which are sometimes found upon their coasts have been hurled up from the sea by the force of the waves.

There are four different kinds of coral formations,—namely: *Lagoon Islands*, or *Atolls*, *Encircling Reefs*, *Barrier Reefs*, and *Coral Fringes*. The first three occur only in the Pacific and Indian Oceans, while the latter are found in some parts of the Atlantic, as in portions of the West Indies, and also in various other localities in the three great oceans.

LAGOON ISLAND, OR ATOLL (SOUTH PACIFIC).

8. **Lagoon Islands.**—A lagoon island, or atoll, consists of a ring of coral enclosing a lagoon,—a portion of the ocean. The width of this ring above the water from the main ocean to the lagoon is, on an average, about a quarter of a mile, and its height above the sea is usually not greater than from six to twelve feet. So low, indeed, are these islands that they are imperceptible, even at a short distance, unless they are clothed with the foliage of the palm, cocoanut, and pandanus, as is frequently the case.

On the *outer* side the coral ring slopes down into the sea for a distance of from three hundred to six hundred feet from the shore-edge,—the water gradually deepening to about one hundred and fifty feet: beyond this point the sides sink suddenly to an unfathomable depth. On the *inner* side the ring shelves into the lagoon by a succession of ledges of living coral, the polyps being of a different species from those which construct the outer portion of the ring. The depth of the lagoon varies from one hundred and twenty to three hundred feet.

Lagoon islands are sometimes circular, but are more usually oval,

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Describe the new islands that have been formed in the Bay of Santorini, with their attendant phenomena. 7. How are coral islands formed? Where do the coral polyps abound? What is coral? What is coral rock? What is said of the variety of form in the coral structures? What are the limits of the zone of the coral formations? Describe the work and nature of the coral polyp. How does Mr. Darwin account for the great height of the coral formations? How is the existence of coral above the ocean-level explained? State the different kinds of coral formations. Where are they found? 8. What is a lagoon island, or atoll? Describe it in full.

or irregular in form. They have openings in the ring, through which the tide enters, and ships find secure harbors within their protecting barriers. Their length varies in their greatest extent from two to about ninety miles. The atoll of Suadiva is forty-four miles long and thirty-four broad; while one, belonging to the Maldive group, has a length of eighty-eight miles, and is from ten to twenty miles across.

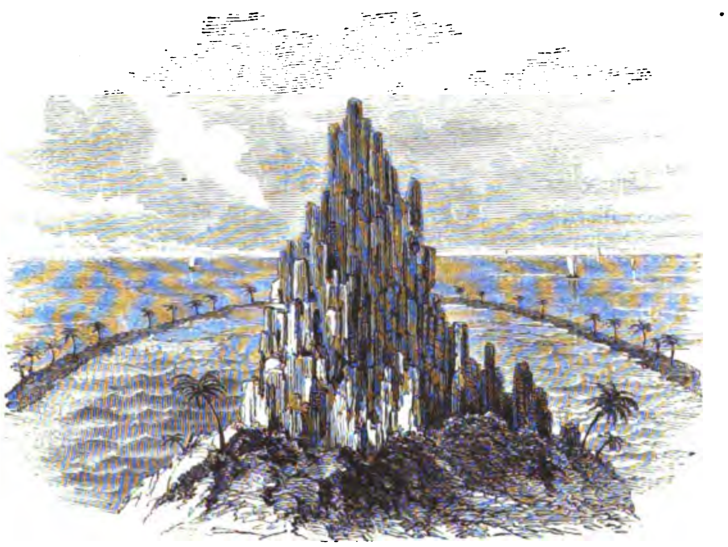
Islands of this class occur both singly and in groups; but they are usually found in extended archipelagoes. The most remarkable instances of this kind in the Pacific Ocean are the Dangerous and Caroline Archipelagoes.

Dangerous Archipelago, which lies east of the Society Islands, is composed of eighty atolls, generally circular, surrounding very deep lagoons. The coral rings rise ten feet above the sea, which beats upon them with tremendous force.

The Caroline Archipelago, which is north of Papua or New Guinea, surpasses all others in size, containing no less than *sixty groups* of atolls, stretching through a distance of more than twelve hundred miles. Many of these are of great extent, and all are exposed to hurricanes and the sweep of violent seas.

The Maldive, Laccadive, and Chagos Archipelagoes, running southward from the western extremity of the peninsula of India, exhibit the same formation. The Maldive group is four hundred and seventy miles long and fifty miles broad, the atolls being arranged in a double row, separated by a sea of unknown depth. The Laccadives lie north of the latter, and consist of atolls nearly circular, extended, like those of the Maldive group, in a double row.

9. **Encircling Reefs.**—These differ from atolls only in the fact that, within the lagoon, one or more islands occur, which are usually of great height, and at a distance of two or three miles from the shore. The encircling reef rises on the outside from a very deep ocean, and, within, is separated from the island by a circular channel from two hundred to three hundred feet deep: the reef, it is supposed, surrounds the submarine base of the island.



ENCIRCLING REEF. (BALABALA, IN THE PACIFIC.)

In the Caroline Archipelago the island of Hogoleu exhibits a fine example of the structure. Here the coral rampart is one hundred and thirty-five miles in circuit, having channels so wide and deep that ships of the largest size can enter the lagoon with ease and moor in safety. Within the lagoon are six or eight islands, which rise to a considerable height.

Tahiti, the chief of the Society Islands, affords a similar instance, and one of remarkable beauty. Encircled by a narrow coral reef, from which it is separated by a lagoon one hundred and eighty feet deep and from half a mile to three miles broad, the island towers in the midst to the height of seven thousand feet, its lofty sides clothed with forests of cocoanut, bread-fruit, and palms, and all the rich and varied productions of a tropic clime.

10. **Barrier Reefs.**—Barrier reefs are vast coral walls, running parallel to the coasts of a continent or an island,—in the latter case skirting only a portion of the shore. New Caledonia has a reef of this kind, which extends for a distance of four hundred miles along one side and around the two ends of the island.

But the finest instance of this structure is the Great Barrier Reef on the northeastern coast of Australia, which traverses the ocean for more than one thousand miles. This wonderful rampart, ranging in breadth from six hundred to five thousand feet, rises from a sea of unfathomable depth, and sweeps along at a distance from the shore varying from twenty to seventy miles. Throughout its whole line it is nearly unbroken, a few openings only admitting vessels into its vast sound, which is navigable from end to end, the water being from sixty to three hundred and sixty feet deep. Upon this mighty barrier the ocean falls with prodigious power, long lines of breakers, miles in extent, thundering over the defiant reef, and descending in continuous cataracts of foam.

11. **Coral Fringes.**—These are simply belts of coral that line the shores in coralline seas. A great extent of coast is skirted by these reefs, which, as they often surround shoals, are very dangerous. Where the coral sinks abruptly they are only a few yards wide; but where it slopes gently beneath the waves the reef is broader, frequently stretching out a mile from the land.

12. There are reasons for believing that a large part of the Pacific in the tropical regions was once occupied by a continent, some portions of which slowly sinking below the level of the sea, the tops of the mountains and table-land were changed into the islands and archipelagoes that now exist. This theory, according to Darwin, who has fully explored the coralline seas, will explain all the varied appearances presented by the coral formations.

13. **Size and Arrangement of Islands.**—Islands vary in size, from the smallest spots upon which the sea-fowl rests, to immense masses of land that embrace kingdoms and vie with continents in their dimensions. Chief among them is Australia, which is nearly as large as Europe, containing an area of about 3,000,000 square miles,—a region rich in gold, but diverse from other countries in almost every particular. Its flowers are without fragrance, its birds without song, and its forms of animal life are extremely singular and unique.

Islands, as we have seen, exist commonly in groups and archipelagoes, and seldom occur alone. Single islands are usually small, and volcanic in their origin. The most remarkable instances of this class are Ascension Island and St. Helena. The former is six hundred and eighty miles from the latter, fourteen hundred and fifty

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What is said of the form of lagoon islands? What of their length and breadth? Give instances of large atolls. What arrangement prevails in lagoon islands? Describe the most remarkable instances. 9. What are encircling reefs? Describe them. Give the examples cited. 10. What are barrier reefs? Describe the reef of New Caledonia. Describe the Great Barrier Reef of Australia. 11. What are coral fringes? 12. How are the coral formations accounted for by Darwin? 13. What is said of the size and arrangement of islands? What is said of Australia? What are the most noted single islands?

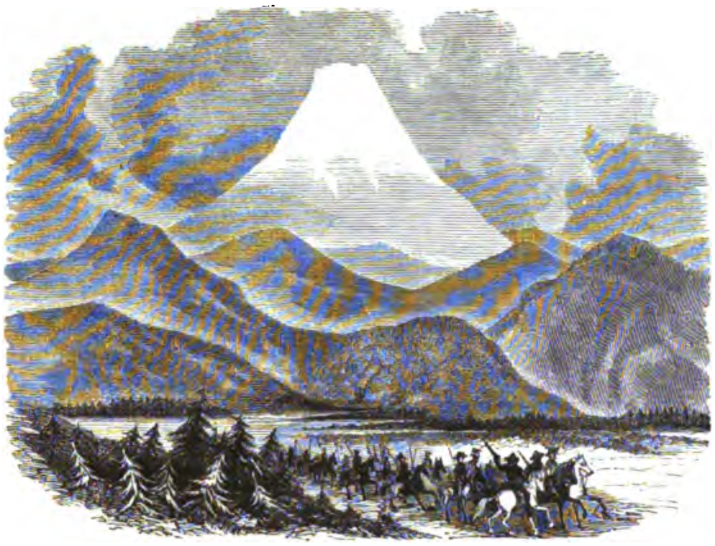
from the African coast, and five hundred and twenty from St. Matthew, which is the nearest land. St. Helena is eighteen hundred miles from the coast of Brazil, and twelve hundred from Africa, the least distant shores being those of Ascension. It rises abruptly from the ocean, a huge mass of frowning volcanic rock, and has acquired celebrity as having been the prison-home of Napoleon Bonaparte after his final defeat at Waterloo.

CHAPTER III.

MOUNTAINS, VALLEYS, AND PASSES.

1. Thus far we have viewed the land in respect to its horizontal outline, or *contour*. We are now to describe it in respect to its *relief*, or elevation above the ocean, under the three great divisions of *Mountains*, with their valleys and passes, *Table-lands*, and *Plains*.

2. **Mountains and their Structure.**—Mountains are the higher elevations of the land, and vary in altitude from the height of twenty-nine thousand one hundred feet to two thousand feet above the sea-level. All inferior elevations are termed *hills*.



MOUNT HOOD. (From the United States Explorations and Surveys.)

Single mountains, unconnected with similar eminences, are of rare occurrence, and the instances that exist are chiefly volcanic in their nature. Such are Mount Egmont in New Zealand, Stromboli in the Mediterranean, and the Peak of Teneriffe on one of the Canary Islands.

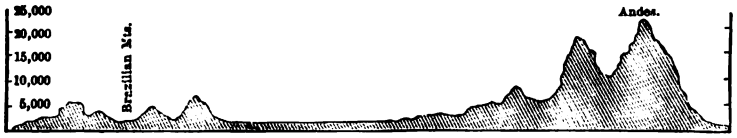
3. These grand natural features generally consist of lofty protuberances united to each other at their bases by ridges, forming together a *mountain-range.* The ranges commonly run parallel to one another, and, when numerous, constitute a vast *chain* or *mountain-system.* In these systems the central range is usually higher and grander than the rest, its towering peaks overtopping the summits on either side. It is also worthy of note that the extremities of a chain are, for the most part, its lowest elevations, while the loftiest points are found near the centre.

From the main system secondary chains not unfrequently branch off at different angles, as in the case of the Ghauts in India, and of the Apennines in Italy. Mountain-chains usually run in the direction of the greatest length of the continents and regions where they occur; but their course is by no means unvarying; for they are seen now sweeping along in curves, and then deviating again and again from the prevailing direction in angles of greater or less extent.

PEAK OF TENERIFFE, CANARIES.

The vast chain in America, formed by the Rocky Mountains and the Andes, and the immense system which, under various names, stretches from the Pyrenees, in Europe, through the Caucasus and Himalayas to the northeast coast of Asia, afford the most striking illustrations of this law. It is exemplified also in the secondary chains; for the Kiölen Mountains in Norway, the Kamtschatka ranges, and the Ghauts and the Apennines, extend through the length of their respective peninsulas.

4. **Slopes.**—In all the continents the surface rises gradually from the sea-shore to the high mountain-systems of the interior; but these do not occupy a central position; and, on this account, a gentle broken slope usually exists on one side of the chain, and an abrupt descent on the other. Thus, the Andes descend rapidly towards the Pacific, but gradually towards the Atlantic; and the Atlas and Taurus Mountains present their most rugged sides to the Mediterranean. The Pyrenees are also steeper towards the south than towards the north; while in the Cantabrian Mountains the reverse is true. In the United States the Alleghanies exhibit the same structure, descending abruptly towards the east and sloping towards the west.



PROFILE OF SOUTH AMERICA FROM THE ATLANTIC TO THE PACIFIC.

According to Malte Brun, this peculiarity is subject to no constant rule, but is dependent upon local causes: yet it appears to be the case that the slope is commonly towards the mainland, while the steep declivity faces the sea. This feature is particularly marked in the contiguous ranges of the Pyrenees and Cantabrian Mountains, where, as just stated, the positions of the precipitous sides are

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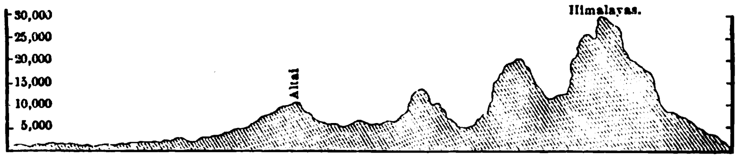
What is the subject of Chapter III.? 1. How has the land thus far been described? How are we now to consider it? 2. What are mountains? What are hills? What is said of single mountains? Give examples. 3. Describe the structure of mountains. What is said of secondary chains? In what direction do mountain-systems run? Give examples. What secondary chains exemplify this law? 4. How does the land rise in all the continents? How do the ascents differ? Give examples. What are Malte Brun's views? What appears to be the rule? Cite illustrations.

reversed. A glance at the map shows that the Bay of Biscay is north of the Cantabrian Mountains, and the mainland of Spain towards the south; while the empire of France lies north of the Pyrenees, and the Mediterranean breaks upon this range at its southern extremity.

5. **Relation between Mountain-Systems and Oceans.**—According to Professor Dana, the highest mountain, in all the grand divisions of the globe, faces the larger ocean. Thus, in the Western Hemisphere the lofty chain of the Rocky Mountains and Andes looks towards the vast Pacific; while the lower ranges of the Alleghanies and Brazilian Mountains face the lesser Atlantic.

In the Eastern Hemisphere the same law obtains. In Asia, the Himalayas, the highest mountains in the world, look down upon the largest expanse of ocean on the globe; while the lower Altai system skirts the great Siberian plain, washed by the Arctic Ocean.

In Africa the loftiest peaks are on the side of the Indian Ocean, and in Australia they are directed towards the Pacific, the larger of its bordering oceans.



PROFILE OF ASIA FROM THE ARCTIC OCEAN TO THE BAY OF BENGAL.

6. So numerous are the ranges, and their adjacent valleys, which form a mountain-system, that it is often hundreds of miles broad, and, with its infinite variety of surface, presents a diversity of scenery exceedingly sublime and beautiful. Here a bold range is seen sweeping along for leagues, clothed with stately forests overtopped by frowning cliffs, and, beyond, a mightier one, with its sides ploughed by the glacier and the torrent, and its towering summits crowned with perpetual snow.

These are all intersected by valleys and broad table-lands, which, in the higher elevations, as in the Himalayas and the Andes, are bleak and sterile; but, at lower altitudes, vales of enchanting beauty spread out between these vast chains. Such is the famous Vale of Cashmere, called by the Orientals the "Paradise of India," and the "Garden of Eternal Spring." Encircled by the colossal ranges of the Himalayas, and having an altitude of seven thousand feet above the sea-level, this lovely region enjoys a mild and temperate climate. Well watered and fertile, it teems with delicious fruits and fragrant flowers; and the rich productions of the soil are equalled only by the surpassing beauty of the landscape.

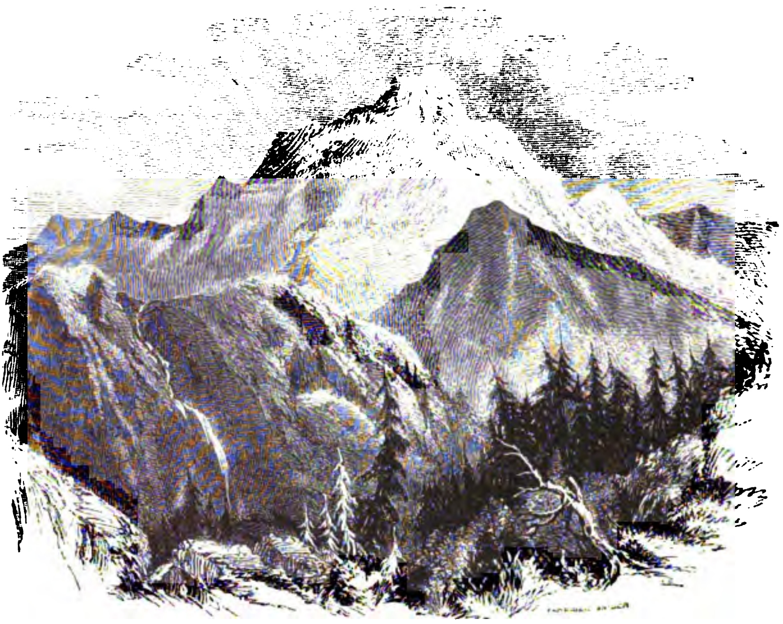
The two great divisions of the land—the Eastern and the Western Hemisphere—exhibit a remarkable contrast in respect to their reliefs: in the former the mountains and table-lands predominate, and in the latter the plains.

MOUNTAIN-SYSTEMS OF THE WESTERN CONTINENT.

7. **There are six mountain-systems** in the Western Continent,—three in North America and three in South America: namely, the Rocky Mountain, the Pacific, and the Appalachian or Alleghany systems in the former; and the Andean, Parime, and Brazilian systems in the latter.

North American Mountain-Systems.

8. **Rocky Mountain System.**—These lofty mountains—which run generally in two, and, in some regions, in three, parallel chains—begin on the north at the Arctic Ocean, near the parallel of 70° north latitude, and extend, in a southeasterly direction, to a mountain-knot near the sources of the Arkansas, in about 40° north latitude, from which point the southward ranges diverge.



PIKE'S PEAK, ROCKY RANGE.

The eastern chain rises as a vast broken wall, with huge mountain-masses jutting out like buttresses upon the great eastern plain. Between these two chains lies the noble valley of Santa Fé, fifty miles broad at its northern extremity. The loftiest peaks of this system are Mount Brown and Mount Hooker,—the former being 16,000 feet high, and the latter 15,700 feet.

VOLCANOES OF POPOCATEPETL AND IZTACCIHUATL, MEXICO.

From these culminating points the chain sinks gradually towards the Arctic Ocean; but even in 62° north latitude its height varies

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5. What relation exists between the ocean and mountain-systems? Give illustrations. 6. What is said of the extent of mountain-systems? What of their diversity of scenery? What is said of the Vale of Cashmere? In what particular do the continents differ? 7. How many mountain-systems are found in the Western Continent? How many in North America, and how many in South America? Name them. 8. Describe the Rocky Mountain system. Name its loftiest peaks.

from 3000 to 4000 feet above the sea. Beyond the mountain-knot, near the parallel of 40° north latitude, this mighty barrier assumes the name of the Sierra[1] Madre; and, extending through Mexico, bounds on the west its beautiful table-land, and rises south of the city of Mexico, in the towering volcanic cones of Popocatepetl and Iztaccihuatl, to the respective heights of 17,720 and 15,300 feet. Thence, stretching towards the south, it is prolonged in the vast volcanic zone of Central America, and terminates at the Isthmus of Panama. The entire length of this immense chain is estimated at five thousand eight hundred miles, and its greatest distance from the Pacific is about nine hundred and thirty miles.

9. **Pacific System.**—This chain runs west of the Rocky Mountains along the Pacific coast, from which it is never distant more than about one hundred and seventy-five miles. It begins at the north, in about the same latitude as the Rocky Mountains, and extends southward under the names of the Beaver Mountains, Cascade Range, and Sierra Nevada, and, embracing the mountains of Lower California, ends at Cape St. Lucas.

MOUNT ST. ELIAS, PACIFIC SLOPE.

On the north, Mount St. Elias, the loftiest land in North America, attains the altitude of 17,900 feet; while in the Cascade Range the gigantic peaks of Mount Hood and Mount St. Helens lift their summits above the ocean,—the former to the height of 14,000 feet, and the latter to the altitude of 13,300 feet.

As this system extends southward, its altitude and breadth diminish, till, in Lower California, it becomes a single ridge, and bears the name of the Sierra St. Lucia.

The Rocky Mountain and Pacific systems, with the plateaus existing between them, have been included under the general name of the Andes of North America, and constitute one of the highest and largest mountain-systems of the globe. The bulk of the uplifted land surpasses that of the South American Andes, being twice as broad as the latter, and exceeding it in length by a thousand miles.

10. **The Alleghany, or Appalachian, System.**—This chain comprises the mountain-ranges on the Atlantic Ocean, and extends southwesterly, under various names, from Labrador as far as Northern Alabama and Georgia, to about 34° north latitude. It begins on the north with the Wotchish Mountains, which are situated to the north of the Gulf of St. Lawrence. South of this belt commence the ranges of the Notre Dame, White, Adirondack, and Green Mountains, and these are succeeded by the Alleghanies, which are prolonged to the southern extremity of this mountain-zone.

The entire length of this chain is about two thousand miles, with a breadth varying from one hundred and fifty to two hundred miles. It is a complex system, composed of numerous parallel ridges whose summits seldom rise higher than about four thousand feet above the sea. Its loftiest peak on the north is Mount Washington, in New Hampshire, 6234 feet in height; while, higher than all others in this chain, Mount Buckley in North Carolina rises to the altitude of 6775 feet.

11. Ranges of mountains are found traversing the three principal West Indian islands,—namely, Cuba, Hayti, and Jamaica. The mountain-zone of Cuba divides the island into two unequal parts,—the highest elevation being at the southeastern extremity, where the Sierra del Cobre reaches the altitude of 7200 feet.

Two principal mountain-chains extend through Hayti, the highest of which is the Cibao Mountains, which rise to the height of 8600 feet above the sea-level. In Jamaica the Blue Mountains, with their varied aspects of grandeur and beauty, run through the whole length of the island. The three highest peaks of its principal range, called the Cold Ridge, have, according to some authorities, the respective heights of 8184, 7656, and 7576 feet above the ocean.

SOUTH AMERICAN MOUNTAIN-SYSTEMS.

12. **The System of the Andes.**—This magnificent chain extends southward from the Isthmus of Panama on the north, through the whole length of South America, along the Pacific coast, terminating in the rugged promontory of Cape Horn. Its component

WINTER SCENE IN THE ANDES OF CHILI.

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[1] *Sierra*, a Spanish word, from the Latin *serra*, a saw; meaning a mountain-ridge.

Where does the Sierra Madre begin? What volcanic mountains rise south of the city of Mexico? Trace this chain south of Mexico. What is its entire length? What its breadth? 9. Describe the Pacific chain. What is its culminating point? What other peaks are mentioned, and what are their respective heights? As this system extends southward, what is said of its height and breadth? What general name has been given to the two systems just described? How do they compare with the South American Andes? 10. Describe the Alleghany system. What are its highest points? 11. Describe the mountain-systems in Cuba, Hayti, and Jamaica.

systems are the Andes of Colombia, and the Andes of Ecuador, Peru, Bolivia, and Chili. In Colombia the chain consists of *three* vast parallel ranges,—namely, the *Eastern*, *Central*, and *Western Cordilleras*;[1] but in Ecuador it is composed of only two. In Peru, the Andes extend northward from the knot of Pasco, in 10° 42′ south latitude, in three immense belts, as in Colombia, and to the south in two mighty ranges to the Chilian Andes. The latter, consisting of a single ridge about thirty miles broad, is prolonged in this form through Chili and Patagonia to Cape Horn.

For six hundred and fifty miles along the coast, the Patagonian Andes rise from the depths of the Pacific,—colossal walls of rock, split by yawning fissures like the fiords of Norway, and ending in huge glaciers towards the sea.

The stupendous system of the Andes has a length of four thousand eight hundred miles, and a breadth varying from forty to three hundred and fifty miles. It is one of the loftiest chains in the world, its average elevation being nearly 12,000 feet, while its base covers an area which has been estimated at 531,000 square (geographical) miles. Twenty of its peaks, according to Herschel, attain an altitude of more than 19,000 feet. Chief among them is Aconcagua, in Chili, which lifts its snowy top to the height of 23,100 feet, while Chimborazo, with its summit 21,420 feet above the sea-level, ranks next in altitude.

PEAK OF ACONCAGUA.

13. **Mountain-System of Parime.**—This system consists of a group of irregular mountain-ranges of moderate extent, which traverse, in various directions, the elevated region embraced by the Orinoco and Amazon Rivers; among them are the Sierras Acaray, Parime, and Pacaraima. The culminating point in this system is found in the latter range, which rises, in the peak of Roraima, to the height of 7150 feet above the ocean. North of the Parime system lies the coast-chain of Venezuela, at whose western extremity the snowy peak of St. Martha reaches an elevation of 19,000 feet.

14. **Brazilian System.**—Like the Parime chain, the Brazilian Mountains form an isolated group, extending from Cape St. Roque to the river La Plata, at varying distances from the coast, and possessing an average height of 3200 feet. The most easterly ranges, under different names, run nearly parallel to the Atlantic coast for a distance of seven hundred miles, with a breadth of about four hundred miles. The mountains of the interior are apparently connected, and form a chain whose general direction is from east to west. From one of these mountains rises the peak of Itambe, 5960 feet high,—the loftiest elevation in Brazil.

MOUNTAIN-SYSTEMS OF THE EASTERN CONTINENT.

15. The mountains of the Eastern Continent are mostly comprised in an immense belt, which, in its main direction, extends from west to east through the centre of the continent,—from Northern Africa and Portugal to Behring Strait. It stretches through more than one hundred and eighty degrees of longitude, and has a length of about nine thousand miles. Unlike the great American systems, which run in distinct and continuous lines, with few lateral ranges, this vast zone consists of a maze of mountains, the principal chains extending, commonly, east and west, and their numerous subordinate ranges north and south. It is divided into *three* groups of systems,—to wit, the *European*, *Asiatic*, and *African* systems; to which may be added the *Australian*.

EUROPEAN SYSTEMS.

16. Seven systems are found in Europe,—namely, the *Scandinavian*, *British*, *Sardo-Corsican*, *Spanish*, *Alpine*, *Caucasian*, and *Ural*. The Sarmatian ranges have sometimes been classed as an eighth system; but, as their greatest elevations—the Valdai Hills—rise no higher than 1100 feet, they cannot properly be termed mountains.

17. **Scandinavian System.**—This chain comprises the mountains of Norway, Sweden, Lapland, and Finland, and extends along the entire coast of Norway for the space of one thousand miles, under the names of the Dovrefield, Langfield, and Kiölen Mountains. They rise for the most part above the snow-limit, and the highest peak is Sneehättan, about 8000 feet above the sea.

18. **British System.**—This is one of low elevation, the highest summit being Ben Cruachan, in Scotland, which attains an altitude of nearly 5000 feet. Its chief component ranges are the Grampians in Scotland, the Cumberland Mountains in England, and the Cambrian in Wales, together with those of Ireland. The Grampians have many ranges from 2000 to 3500 feet high. In England the culminating point is Sca Fell, in the Cumberland Mountains, which rises 3166 feet above the sea. Snowdon, 3571 feet high, is the loftiest peak in Wales; and in Ireland, Carran Tual—rising above all others—attains an altitude of 3400 feet.

19. **Sardo-Corsican System.**—Within this system, as its name implies, are embraced the mountains of the islands of Sardinia and Corsica. It extends in the direction of the length of the two islands, being broken by the Strait of Bonifacio. It is a high, rugged, and irregular chain, and culminates in Monte Rotondo in Corsica, which rises to the height of 8767 feet.

20. **Spanish System.**—This includes all the mountains of Spain

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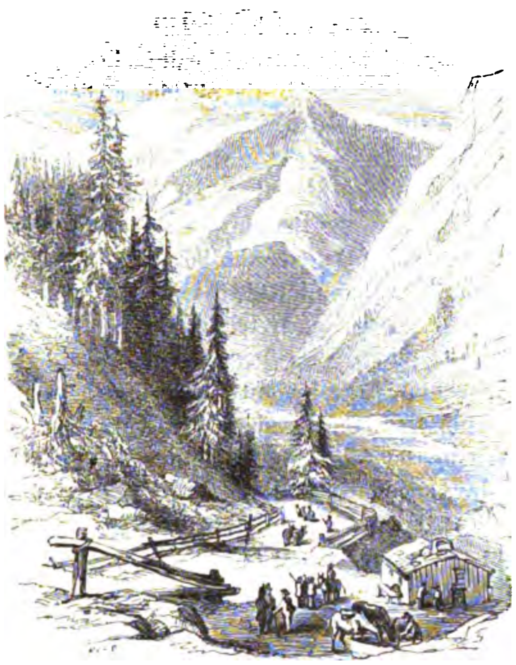
[1] According to Dr. Tschudi, the *western* ranges are properly the Cordilleras, and the *eastern* the Andes.

What are the extent and magnitude of the Andes? How many points in this chain rise higher than 19,000 feet above the sea? What peaks tower highest above the sea? 13. Describe the Parime system. 14. Give an account of the Brazilian system. 15. State what is said respecting the mountain-systems of the Eastern Continent. What three groups of systems does it contain? 16. Name the European systems. Do the Sarmatian ranges constitute properly a system? 17. What is said of the Scandinavian system? 18. What of the British system? 19. Describe the Sardo-Corsican system. 20. What is said of the Spanish system?

and Portugal, together with those of France south of the Garonne. Its component chains are the Pyrenees and Cantabrian ranges, the Sierra Morena, the Mountains of Castile, and the Sierra Nevada, which terminates in the frowning rock of Gibraltar. The culminating point in this system is the peak of Mulahacen, which rises from the Sierra Nevada to the height of 11,660 feet. The great chain of the Pyrenees extends from the Bay of Biscay to the Mediterranean Sea, forming a natural rampart between France and Spain. Its principal crest is a wavy line, having an average altitude of 7000 feet, but broken by numerous peaks, the loftiest of which is Mount Maladetta, 11,168 feet high.

21. **Alpine System.**—This is the noblest and most complex of all the European systems, covering the whole of Central and part of Southern Europe, and culminating in crests and peaks of unrivalled sublimity and beauty.

The principal chain, which is remarkably continuous, stretches from Genoa to Vienna in Lower Austria. Taking as a standpoint the mountain-knot of St. Gothard, this vast system is developed towards the west in the masses of the Jura Mountains, and, beyond these, is connected, through the Cévennes range in Southern France, with the chain of the Pyrenees; while, branching off northward from the Jura range, the Vosges Mountains extend through the Valley of the Rhine.


THE ALPS, SWITZERLAND.

Southward from St. Gothard the Alps sweep round in a magnificent curve to Genoa, and are extended in the long chain of the Apennines through the whole length of Italy. Nor does this chain terminate in the Italian peninsula; for it may be regarded as prolonged into Sicily, where it rises to the height of 10,874 feet in the active volcano of Mount Etna.

Now advancing to the east, we see this great system sending down southward another long range, forming the Pindus Mountains, which run parallel to the Adriatic Sea, traverse Albania and Greece, and rise to a lofty elevation in the classic peaks of Olympus and Parnassus. Eastward of the Pindus range lie the Balkan Mountains, —a rugged and broken chain, which extends as far as the Black Sea, embracing the bold barrier of the ancient Hæmus, 8874 feet high.

Still farther on, the Alpine chain branches off to the north in the Hartz and Sudetic Mountains; and last, closing this great system, succeed the Carpathian Mountains, which enclose on the east the plains of Hungary within the vast sweep of their semicircular chain. The most prominent of its component ranges is Mount Tatra, a rocky mass 7000 feet high and 50 miles long,—reaching in the peak of Ruska Poyana an elevation of 9912 feet.

ALPINE VILLAGE.

Mont Blanc and Monte Rosa are the loftiest peaks of the Alpine system,—the former rising to the height of 15,668 feet above the sea, and the latter 15,223 feet. The base of the higher Alps is estimated by Humboldt to contain an area of 24,300 square (geographical) miles.

22. **Caucasian System.**—Stretching between the Black and Caspian Seas is the Caucasian chain, which separates Europe from Asia. It is seven hundred miles long, and has a breadth varying from sixty to one hundred and twenty miles. Numerous spurs branch off from the main chain, whose highest summit is Mount Elburus, 17,776 feet above the ocean.

23. **Ural System.**—This chain is a narrow mountain-zone dividing Europe from Asia, and hardly anywhere presents the usual features of a mountain-system. It runs northward to the Arctic Ocean, and is prolonged to the eastern extremity of Nova Zembla,—a distance of seventeen hundred geographical miles. These mountains are rugged and precipitous, and abound in rich deposits of gold and malachite.

MOUNTAIN-SYSTEMS OF ASIA.

24. The mountains of Asia are comprised in six systems,—namely, the *Asia Minor*, *Hindoostan*, *Assam*, *Kuen-Lun*, *Thian-Shan*, and *Altai* systems.

25. **Asia Minor System.**—Passing over the Sea of Marmora from Europe into Asia, the grand mountain-zone of the Eastern Continent is revealed in the ranges of the Taurus and Anti-Taurus, each of which towers in bold peaks to an altitude of 13,000 feet.

The former, skirting the shores of the Mediterranean, is connected on the south with the ranges of Lebanon and Anti-Lebanon, which are prolonged through Syria to Mount Hermon, 10,000 feet high, and thence through Palestine to the Red Sea, where the sacred mountain of Horeb, from the height of 8593 feet, looks down upon its waves. Stretching southerly beyond this point, along the Arabian shore, the mountain-belt sinks in altitude till it reaches Medina; then, rising, it skirts the Red Sea coast as far as Aden.

To the east the Taurus range extends into Armenia, and reaches its highest point in Mount Ararat, 17,210 feet above the sea. Southward of Ararat are the Zagros Mountains, stretching through Kur-

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21. Describe in detail the Alpine system. What are the names of the two highest peaks in the Alpine system? How high are they? What area do the higher Alps cover? 22. Describe the Caucasian system. What is the name of its highest summit? 23. Describe the Ural system. 24. Give the number and names of the mountain-systems of Asia. 25. Describe the Asia Minor system.

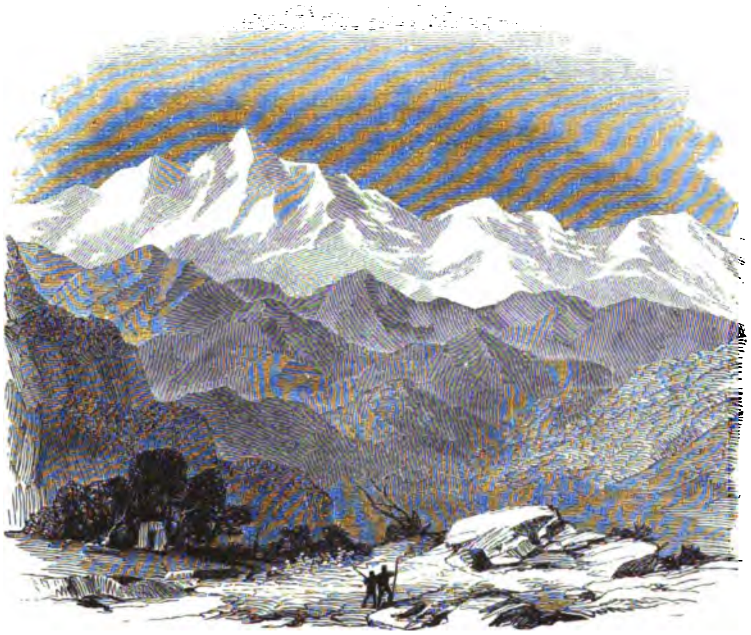
distan and continued in numerous ranges to the Persian Gulf and the Indian Ocean.

The Anti-Taurus, sweeping along the southern shores of the Black Sea, meets with the chain of the Caucasus coming down on the northeastern side. From this knot the great mountain-belt, advancing eastward, bends round the southern coast of the Caspian Sea, under the name of the Elborz Mountains, and culminates in the peak of Demavend, 14,660 feet high. Bounding Persia on the north, it stretches along in parallel ranges to Herat, where it joins the chain of the Hindoo Koosh.

26. **Mountain-System of Hindoostan.**—This consists, *first*, of the vast and complex ranges of the Hindoo Koosh, and, *secondly*, of the minor ranges of the Indian peninsula; the whole forming an immense network of mountain-ramparts, enclosing various tablelands and plains.

27. *Hindoo Koosh.*—The great mountain-zone which we have traced in its course from the western shores of Europe, is here developed in its most magnificent and sublime forms. From Herat it extends eastward in two ranges,—that on the south entering India by the pass of Cabul, close to the Koosh Mountain, 20,000 feet high, which gives its name to the whole chain; and, sending down towards the south the Huzareh and Suliman Mountains, stretches on to the lovely Vale of Cashmere.

The northern range, which is here somewhat broken, unites—in the vicinity of the Beloor Mountains and of the sources of the Ganges and Sutlege—with a maze of mountain-masses of the grandest forms. To the east it is prolonged in the Kuen-Lun Mountains; while to the southwest the stupendous chain of the Himalayas, with its colossal peaks and immense transverse spurs, sweeps down in a vast curve to Bootan, and up to Assam,—a distance of thirteen hundred geographical miles.



HIMALAYAS. SNOWY RANGE.

This chain, the loftiest in the world, abounds with scenery surpassingly magnificent and sublime. Gorges and abysses are here beheld so deep and narrow, and overhung by precipices of such tremendous height, that the rays of only a vertical sun can pierce the thick gloom that shrouds their depths; while more than forty peaks, uprising from the spurs of this mighty chain, lift their snowy tops to altitudes exceeding 20,000 feet. Peerless among them towers Mount Everest, whose glittering crest—the culminating point of the globe—is 29,100 feet above the sea.

28. *Ranges of the Peninsula.*—South of the Himalayas various subordinate ranges extend over the peninsula of India, the chief of which are the Aravulli, Vindhya, and Satpoora Mountains, and the Eastern and Western Ghauts.

The Ghauts skirt the Malabar and Coromandel coasts, enclosing the table-land of Deccan, and, uniting beyond Mysore to the south, form the beautiful and salubrious country of the Neilgherry Hills, which rise in the peak of Dodabetta to the height of 8760 feet. This region enjoys almost perpetual spring, and is the general resort in India for those whose health requires the bracing influences of a bland and temperate clime.

The mountains of the peninsula may be regarded as prolonged through Ceylon, the central parts of which are lofty and rugged, and attain their highest elevations in Adam's Peak and the Pedrotallagalla Mountain,—the former reaching the altitude of 7420 feet, while the latter is 8280 feet above the sea.

29. **Assam System.**—The valley of the Brahmaputra terminates on the south the chain of the Himalayas, in about 94° east longitude; while skirting the river on the southeast, rise the mountains of Assam, which are said to possess the bold features of the Himalayas; but as yet they have been but little explored. Beyond them several systems extend southerly, stretching through Birmah, Cochin China, and Siam.

Of these the Birmah chain is the longest, traversing the whole length of the Malacca Peninsula to Cape Romania, its southern point. A parallel chain is seen in the volcanic mountain-zone that runs through Sumatra and Java; while Borneo, on the east, sends down from the north, throughout its entire length, magnificent belts and ridges, which end in three chains on the Java Sea.

30. **Kuen-Lun System.**—Issuing from the same mountain-knot as the Himalayas, the chain of the Kuen-Lun forms the southern barrier of the table-lands of Central Asia, and, stretching onward towards the Pacific, covers with its numerous ranges the greater part of the Chinese Empire on the south and east. It is volcanic in many parts, and attains in some places an altitude of 20,000 feet.

From its peculiar situation, this system is but partially known. It appears, however, to diverge into three main ranges, between 100° and 110° east longitude, under the names of the Peling, Tapaling, and Yanling Mountains; while to the south, beyond the river Yang-tse-Kiang, the Nanling chain extends from east to west. To the north it sends out a great branch in the In-Shan Mountains, which divide into the Khingan-Oula and Mantchooria ranges, which continue as far as the river Amoor and the Sea of Ochotsk.

31. **The Thian-Shan Mountains** bound on the north the vast and sterile table-land of Upper Tartary, and extend from Samarcand eastward in almost a straight line for a distance of eleven hundred and fifty geographical miles, being in some places one hundred miles broad. This range rises occasionally above the snow-line, and contains many volcanoes, for the most part extinct, though two—the Peshan and Hochow—are still active.

32. **Altai System.**—This system begins at the sources of the

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26. Of what two divisions does the mountain-system of Hindoostan consist? 27. Describe the ranges of the Hindoo Koosh in detail. Give an account of the Himalaya Mountains. 28. Describe the peninsular ranges, and the Ceylon Mountains.

29. Where is the Assam system situated? Describe it. 30. Give an account of the Kuen-Lun system. 31. Describe the Thian-Shan system. 32. Give an account of the Altai system.

Irtysh and Obe Rivers, and, spreading out in numerous branches, is continued to East Cape at Behring Strait. The first series of ranges are the Ala Tagh, Tangnou, and Khiang-Khan Mountains; next succeeds the Daurian belt, between Lake Baikal and the sources of the river Amoor, which, extending easterly, branches off in its course into the Yablonoi, Udskoi, Aldan, Alascisci, and Stanovoi chains, and, crossing the volcanic range of Kamtschatka, is prolonged to Behring Strait.

North of the upper course of the river Lena, a minor range extends from east to west, in the Wiljuish Mountains. This system has an elevation varying from 5000 to 8000 feet above the sea. The mountain-knot of Kentei Khan is from 7000 to 8000 feet high, and the Tangnou ranges rise in several points to the altitude of 11,000 feet. According to Ansted, the chain of the Altai, stretching from the Irtysh to the Sea of Ochotsk, and thence continued north through the Aldan Mountains, has a length of nearly 3500 miles.

33. **Australian System.**—Australia, vying with the grand divisions of the globe in size, claims, with its adjacent islands, a distinct division for its mountain-system. The main ranges of Australia are the Blue Mountains, which extend southward from Cape York, on Torres Strait, into Tasmania, skirting the coast at distances varying from fifty to one hundred and fifty miles from the sea. This chain is wild and rugged, though of moderate elevation, rising, however, in Mount Kosciusko, on the southeastern shore, to the altitude of 6500 feet above the ocean. A lower range, called the Darling Mountains, follows the west coast of Australia from Cape Leeuwin to Northwest Cape.

Beyond Torres Strait this mountain-belt is continued through New Guinea with the same bold features, range rising above range until their crests attain the height of 16,000 feet, and are covered with perpetual snow. Lofty mountain-ranges also run through the island of New Zealand, culminating in Mount Cook, 12,200 feet above the sea.

Mountain-Systems of Africa.

34. Africa has been but partially explored, and our knowledge of this country is therefore imperfect. *Five* principal mountain-systems have, however, been discovered,—namely, the *Atlas, Guinea, Cape, Abyssinian*, and *Eastern Systems.*

35. **Atlas System.**—The Atlas Mountains consist of three or four parallel ranges, running westward between the Mediterranean and the Great Desert, from Tripoli to the Atlantic. The chain increases in altitude as it advances westward; for, while it is only 2000 feet high in Tripoli, the peak of Jebel Tedla, in Morocco, towers above the snow-line, having an altitude of 13,000 feet.

This chain sends down an important branch towards the north, which ends at Ceuta, opposite Gibraltar, revealing a connection between the African Mountains and those of the Spanish peninsula.

36. **Guinea System.**—In Western Africa a mountain-system exists which runs through the whole of Guinea, stretching along the coast from Senegambia to Damara Land. Beginning with the coast-range of Sierra Leone, it is prolonged in the Kong and Cameroons Mountains. The latter run easterly into the heart of the continent to an unknown distance, and have been supposed to connect with the Mountains of the Moon.

The late Captain Speke, in his last journey into Central Africa, received information which led him to believe in the existence of such an equatorial mountain-range, extending west of the great lake of Victoria Nyanza. Beyond the Cameroons, to the south, succeed the Crystal and Mocambe Mountains, which terminate the chain. The northern part of this system is the lowest, the Kong Mountains rising no higher than about 3000 feet; while the Cameroons and southern ranges lift their crests to altitudes varying from 4000 to 14,000 feet above the sea.

37. **Cape System.**—The surface of Southern Africa consists of a series of sandstone terraces, intersected by granite rocks, rising one above the other, from the coast towards the interior, to elevations of 2000, 4000, and 6000 feet above the sea, and extending from the Orange River, on the west, around the Cape of Good Hope, to the Zambezi, on the east. The steps of these terraces consist of rocky ranges and flat-topped mountains, which are termed the *Cape system.*

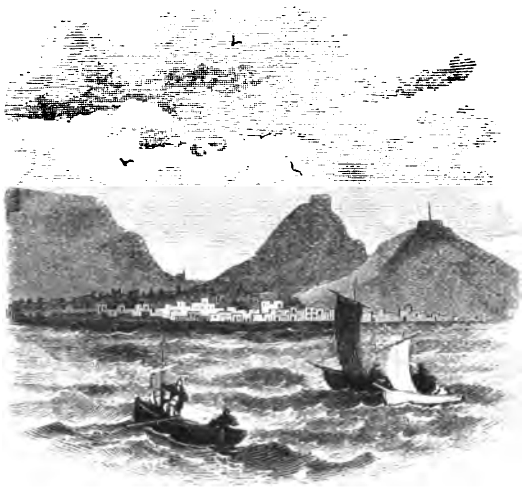

TABLE MOUNTAIN.

The first of these ranges, called the Zwellendam, about twenty miles inland from the Cape coast, rises in Table Mountain to the height of 3600 feet. Behind this is the Black range, and beyond this are several other ranges, which attain in the Snow Mountains the elevation of 10,000 feet.

Parallel to the African coast, grand mountain-chains, rugged and precipitous, traverse the adjacent island of Madagascar for the space of one thousand miles,—its three principal ranges varying in altitude from 8000 to 12,000 feet above the ocean.

38. **Eastern System.**—Beyond the Snow Mountains the Eastern system begins, following the coast of Zanguebar in the Beth and Lupata ranges; while, inland, the lofty chain of the Mountains of the Moon stretches northward, rising in altitude as it approaches the equator. Its highest peaks are Kenia and Kilimanjaro, neither of which is less than 20,000 feet high. Beyond the equator the various ranges of this system appear to sink down and merge in the highlands of Ethiopia and Abyssinia.

39. **Abyssinian System.**—The elevated table-land of Abyssinia is flanked and traversed by rocky ramparts and mountain-barriers, cleft by deep and perilous chasms. The chief ranges are the Samen and the Taranta, which run northerly between the branches of the Upper Nile and the Red Sea, and, running along the shores of the latter, connect by the low hills of Egypt, through the Isthmus of Suez, with the Syrian Mountains.

The rugged range of the Samen is the loftier of the two, rising in the peak of Rus-Detschen to the height of 15,986 feet, while the Taranta reaches no greater altitude than about 9000 feet above the sea.

VALLEYS AND PASSES.

40. Valleys are deep and extensive depressions of land occurring in mountainous districts; but these depressions are simply local; for

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33. Describe the mountain-ranges of the Australian system. 34. What is said respecting our knowledge of Africa? How many mountain-systems have been found in this country? Name them. 35. Describe the Atlas system. 36. Give an account of the Guinea system. 37. Describe the Cape system, and that of Madagascar. 38. Describe the ranges of the Eastern system. 39. Describe the Abyssinian system. 40. Define valleys.

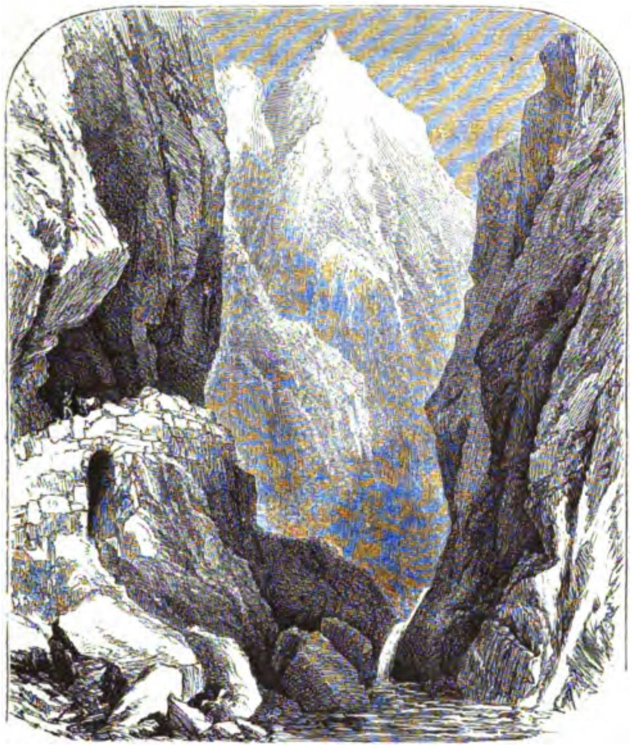
numerous valleys have a higher elevation above the ocean-level than many mountain-ranges.

The names of vales and dales may be appropriately given to the minor depressions of the earth's surface, lying between the lower ridges and hills.

Valleys are divided into two classes, *longitudinal* and *transverse*,—the former running *between* parallel mountain-ranges, while the latter, cutting *through* them at various angles, form *passes* and thoroughfares over these natural barriers.

Among the finest examples of the first kind in the Western Continent are the fertile Valley of Virginia, 700 miles long, flanked by the Blue Ridge and the Alleghanies, and the Valley of the Sacramento and San Joaquin, extending for a distance of 500 miles between the Sierra Nevada and the Coast Range of California.

In the Eastern Continent a remarkable instance is seen in the Canton of the Valais in Switzerland. Bounded on the south by the chain of Mont Blanc and Monte Rosa, and on the north by the Bernese Alps and the lofty crest of the Jungfrau, this noble valley, varying in breadth from two furlongs to three miles, stretches upward between its rocky barriers for nearly a hundred miles to Monte Furca, from whose glaciers bursts the Rhone, which, descending through the whole valley, enters at length the Lake of Geneva.



PASS OF THE VIA MALA.

41. **Passes.**—Transverse valleys are, for the most part, natural highways leading across mountain-chains, and upward from the lower to the higher levels through the depressions and gaps of the ranges. They are then termed *passes*, and are sometimes broad thoroughfares of easy access and lofty elevation. Such is the South Pass,—the great gate of commerce and travel between the Mississippi and the North Pacific. This remarkable gap is twenty miles wide, and has an altitude of 7490 feet above the sea.

But the physical features of these valleys are generally widely different from those of the pass just mentioned; for they are usually nothing more than narrow gorges of tremendous depth and abounding in the wildest scenery. The Vale of Cashmere, walled in by the vast ranges of the Himalayas, is accessible by seven such passes. Three famous defiles pierce the chain of the Caucasus. One of these is the valley of the river Terek, where the road winds, on one side, along the brink of appalling precipices, at whose feet roars the foaming torrent; above, the mountain-cliffs are so lofty, close, and overhanging, that the frightful chasm, even at noonday, is darkened by a twilight gloom. At Dariel, a day's journey up the European side of the pass, the defile presents a scene of surpassing grandeur,—the walls of rock rising nearly 4000 feet above the bed of the river.

The Andes are likewise cleft by tremendous chasms, which furnish but perilous roads across its mighty ranges. The Alpine chain of Europe is also riven by terrific gorges. "Few places," says Brockedon, "are more wild and romantic than the Via Mala, where a deep ravine is formed by the bases of mountains rising 6000, and even 8000, feet above the torrent of the Hinter-Rhin, which separates them. In many places the sides of the ravine are not more than fifty feet apart. The entire length of the defile is four miles, and terminates in the valley of Schams."

42. **Depressions below the Sea-Level.**—Various portions of the earth's surface are below the level of the sea. The most remarkable instance of this kind is the depressed region embracing the Aral and Caspian Seas. It contains about 162,000 square miles, and all of it is below the sea-level. The surface of the Caspian, which is the lowest point, has been determined by the Russian survey to be nearly eighty-four feet below that of the Black Sea.

The valley of the Jordan, though less extensive, is a deeper depression than the one just mentioned; for the surface of the Dead Sea, according to the most recent measurements made by Captain Wilson, in 1865, is in winter 1289 feet, and in summer 1298 feet, below that of the Mediterranean, from which it is only fifty miles distant. It is probable, according to Fournel, that a part of the Great Desert in the north of Africa is lower than the sea-level; and it is known that the salt lake of Bahr Assal, near the Gulf of Aden, is thus depressed to the extent of 570 feet.

One, if not more, of such regions exists in the Western Continent. Dead Man's Valley, in California, situated in about 36° 30′ north latitude and 117° west longitude, is more than 100 feet below the level of the ocean, and is one of a great chain of depressions extending from the Sink of the Humboldt almost to the Gulf of California.

43. **Utility of Mountains.**—Mountains form a most important part of the mechanism of the globe, and are replete with evidences of design and special adaptation. We may therefore with advantage glance at a few of the uses they subserve.

Rising from the sea to the height of many thousand feet, the temperature of mountains gradually decreases until the region of perpetual frost is attained. They thus become the great natural refrigerators of the globe, condensing the vapors of the atmosphere, causing rains and showers to descend upon the land, and giving birth to the mighty rivers of the earth.

It has been seen that the mountains attain their greatest altitudes near the equator; and this arrangement reveals a most beneficent

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What are vales and dales? Into what two classes are valleys divided? How are they distinguished from each other? Give examples of longitudinal valleys. 41. What are passes? What is said of the South Pass? What are the physical features of passes? Are they usually of easy access? What is said respecting those of Cashmere and of the Caucasus? Describe the pass of the Terek. Among what other ranges are remarkable gorges found? Describe the pass of the Via Mala. 42. Are any portions of the earth's surface below the sea-level? Give the instances cited. 43. What is said of the utility of mountains? Are they mere masses of land without adaptation or design? Mention some of the uses that mountains subserve.

provision of the Creator. Had the highest chains been situated in the polar climes, they would have been encased from base to summit with glaciers and snow, and thus rendered uninhabitable; but, placed as they are, a vast extent of surface has been rescued from desolation. All along their lofty sides, and amid their elevated valleys, every variety of climate is found, each with its peculiar type of animal and vegetable life; and these Alpine regions are filled with hardy and energetic races of men.

Mountains are likewise the great depositories of the minerals and precious metals so essential to the civilization and comfort of man. Their rugged barriers have also ever constituted natural boundaries between political communities and different races, and have thus tended to promote the peace and order of the world; and in all ages their fastnesses have been the asylum of Liberty.

Nor must we omit to mention how greatly the scenery of mountains ministers to our love of the beautiful and sublime, and how much would be lost in this respect if the surface of the earth were a monotonous, unbroken plain.

CHAPTER IV.

TABLE-LANDS.

1. **A Table-Land,** or plateau, is a vast elevated region, not less than about two thousand feet above the sea, containing a large extent of level surface. It may be diversified by hills and dales, swell into lofty peaks, and be traversed and flanked by steep precipices and ridges; but a predominance of level expanse is its characteristic feature.

A PLATEAU.

2. The Eastern Continent abounds with plateaus, and nowhere else are they so numerous, elevated, and extensive as in Asia and Africa. In the former the mountains and table-land cover five-sevenths of the surface, and in the latter two-thirds. In the Western Continent only one-third of its area is occupied by these elevated tracts.

It is worthy of remark that the heights of plateaus—and also of plains—increase with the elevations of the mountains above the sea-level; for the loftiest table-lands are found in the vicinity of the equator, where the highest mountain-chains likewise occur.

TABLE-LANDS OF THE WESTERN CONTINENT.

3. There are eight principal table-lands in the Western Continent,—four in North America and four in South America: namely, the Eastern, Great Western, and Mexican Plateaus, and the table-land of Central America, in the former; and the table-lands of Colombia, Ecuador, Peru and Bolivia, and Brazil, in the latter.

TABLE-LANDS OF NORTH AMERICA.

4. **Eastern Plateau of the Rocky Mountains.**—This region consists of a belt of land averaging about three hundred and fifty miles wide, extending northward parallel to the Rocky Mountains on the east, from nearly 28° north latitude to 60° north latitude; and it may even be regarded as prolonged in the highlands east of the Mackenzie River. Its eastern boundary has an altitude of about 2000 feet; and from this margin to the base of the Rocky Mountains the whole zone rises by successive slopes and terraces. Between 38° and 49° north latitude the mean height of the plateau is 4000 feet; but the western portion, or upper plateau, is much higher; for the Laramie plains attain the altitude of 6000 feet.

From the river Pecos to near the forks of the Nebraska the mean height of the upper plateau is about 4000 feet. The whole belt from the former river to the Missouri is a barren desert, without tree or shrub, except on the borders of the slender streams, and, on account of the scarcity of rain, is nearly destitute of vegetation.

5. **Great Western Plateau.**—This immense table-land lies between the Rocky Mountains and the Pacific chain, and stretches, with its northern slopes, from the Arctic Ocean to the Gulf of California. It is widest near the middle, is for the most part sterile, and comprises three great divisions,—namely, the *Great Interior Basin*, the *Northern Plateau*, and the *Southern Basin*.

Great Interior Basin.—This vast table-land lies between the parallels of 37° and 44° north latitude, having a breadth of five hundred miles in every direction, and an altitude varying from four thousand to five thousand feet above the sea. It is shut in on all sides by mountains, and has its own system of lakes and rivers, which have no connection with the ocean. The structure of the interior of the basin is mountainous, with dry and sterile plains; but, although the surface is generally desert, many rich and fertile tracts occur.

Northern Plateau.—North of the Great Interior Basin the Great Western plateau is continued between the Rocky Mountains and the Cascade Range, where it is more contracted, and descends gradually eastward and northward.

Southern Basin.—This region, which is mostly embraced by Arizona, is drained by the Colorado and its tributaries. The extension southward of the Western plateau beyond the Wasatch Mountains exhibits, as far as Mexico, the same succession of table-lands and ridges as characterizes the Great Interior Basin. It is, however,

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Do we see in mountains any adaptations to the wants of our higher nature? What is the subject of Chapter IV.? 1. Define a table-land. 2. In which continent do plateaus most abound? State what is said on this point. What relation exists between the height of table-lands and that of mountains? 3. What is the number of the principal table-lands in the Western Continent? How many are there in North America? How many in South America? 4. Describe the Eastern Plateau. 5. Describe the Great Western Plateau. Describe the Great Interior Basin, the Northern Plateau, and the Southern Basin.

better watered and more fertile than the latter, though north of the river Gila is a tract consisting chiefly of desert table-land.

VIEW IN THE GREAT INTERIOR BASIN.

6. **Mexican Plateau.**—Beyond the Southern Basin begins the Mexican plateau, which extends southeasterly to the Isthmus of Tehuantepec.

Its chief table-lands are those of Chihuahua and Anahuac. That of Chihuahua, north of the parallel of 24°, and east of the rivers Conchas and Florida, is a desert region, having an elevation of from 4000 to 6000 feet above the sea. The table-land of Anahuac, on the contrary, is for the most part fertile, and has a greater altitude, varying in height from 6000 to 8000 feet. This plateau is broadest in the latitude of the city of Mexico, where it is 360 miles wide, but gradually contracts as it advances to the south.

It is traversed in some places by mountain-ridges, and consists of four distinct table-lands. The first and highest is that of Toluca, 8570 feet above the sea; the second, the plateau of Tenochtitlan, whose altitude is 7470 feet; Aclopan, the third, reaches the height of 6450 feet; and Istla, the fourth, has an elevation of 3320 feet above the ocean. These plateaus differ in climate and natural productions.

The table-land of Tenochtitlan is an oval expanse fifty-five miles long and thirty-five miles broad, enclosed by ranges of porphyritic and basaltic rocks, and in its midst stands the famous city of Mexico. East of Mexico, towards Vera Cruz, the plateau continues level for the space of two hundred miles, when it abruptly sinks 3000 feet to the plain. On the west it descends gradually to the lowlands, at the distance of sixty miles from the city.

Two mountain-passes, five hundred miles apart, lead from this lofty expanse to the Gulf of Mexico,—one at Jalapa, near Vera Cruz, and the other at Saltillo, west of Monterey. Through the first of these marched the daring band of Cortez to the conquest of Mexico; and both the defiles were forced by the American army in our war with that country in 1846.

7. **Table-Land of Central America.**—This embraces the minor plateaus of Guatemala, Honduras and Nicaragua, and Costa Rica. That of Guatemala consists of a vast, rolling, and fertile plain rising above the sea to the height of 5000 feet; while to the south the bold highlands of Honduras, crowned with magnificent forests, extend to Nicaragua, where the land sinks down to nearly the sea-level. After an interval of one hundred and seventy miles the land again rises, forming the small plateau of Costa Rica, which consists of two or three terraces encompassed by volcanoes. This tract is considerably elevated; for the town of Carthago, within its limits, is 5000 feet above the sea. Southward from this region stretch the mountains of Veragua, beyond which the land descends to the plains of Panama, almost on a level with the ocean.

TABLE-LANDS OF SOUTH AMERICA.

8. **Table-Land of Colombia.**—Passing southward from Panama, the majestic chain of the Andes is revealed, between whose lofty sierras and frowning crests stretch vast level expanses, some of which possess great beauty and fertility. Amid these elevated regions a busy population is found, and stately cities and flourishing towns exist, abounding with all the comforts, and even the luxuries, of civilized life.

The table-land of Colombia first occurs, consisting of the plateaus of Bogota and Popayan. The first, encircled by lofty mountains, is perfectly level, and attains the height of 8700 feet above the sea. Here is situated Bogota, a city of 45,000 inhabitants, in which are found the manufactures of every part of the globe. The second, having an altitude of 5760 feet, surrounds the city of Popayan, in whose vicinity the main range of the Andes sends up the gigantic peaks of Purace and Nevada de Huila, the latter of which is 17,900 feet high.

9. **Table-Land of Ecuador.**—Directly beneath the equator is the splendid plateau of Ecuador, two hundred miles long and thirty broad, with an average altitude of 10,000 feet above the ocean. It is girded by a rampart of magnificent volcanoes; and nowhere else amid the Andes are found such gigantic mountain-masses as rise on the east and west of this basin. The soil is generally fertile, and covered throughout the year with a rich and abundant vegetation.

Within this plateau, at an elevation of 9540 feet, stands the noble city of Quito, the capital of the second Peruvian monarchy. It contains a population of 76,000, and vies in splendor and luxury with the rich cities of the sea-board in either hemisphere. It is situated on the side of the volcanic mountain Pichincha, which towers 15,922 feet above the sea; while from its heights are seen on the north and south eleven colossal peaks glittering with eternal snow. Many monuments of the ancient Incas still exist throughout this region.

10. **Table-Land of Peru and Bolivia.**—Under this name is included the elevated tract which extends for more than 1000 miles from the mountain-knot at Cuzco to about 30° south latitude. It is remarkable for its vast size and great altitude, having an area of 150,000 square miles; while its varied surface, more than 12,000 feet above the sea, stretches along the Andes midway between the ocean and the loftiest mountain-crests.

At the northern part of this great table-land is the beautiful valley that surrounds the city of Cuzco, the cradle of Peruvian civilization; while the central portion is occupied by the basin of Lake Titicaca, which comprises an area of 39,000 square miles, and is noted for the sublimity of its scenery. It lies between two majestic ranges of the Bolivian Andes, which bound it on the east and west for a distance of 400 miles, their volcanic peaks, girdled with clouds, towering to the height of 8000 feet above this lofty plain. This region abounds

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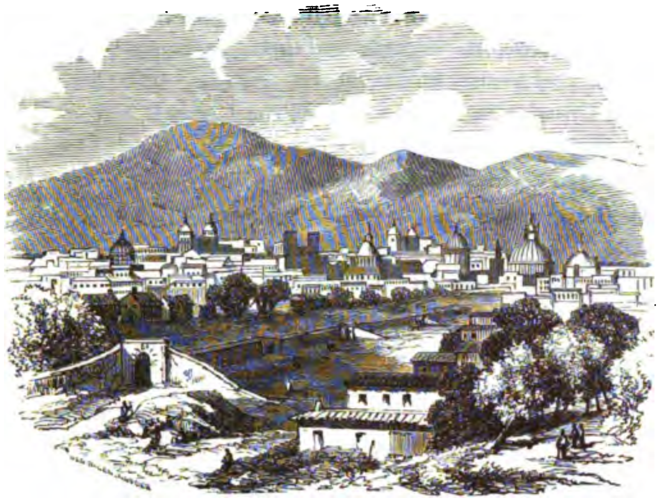
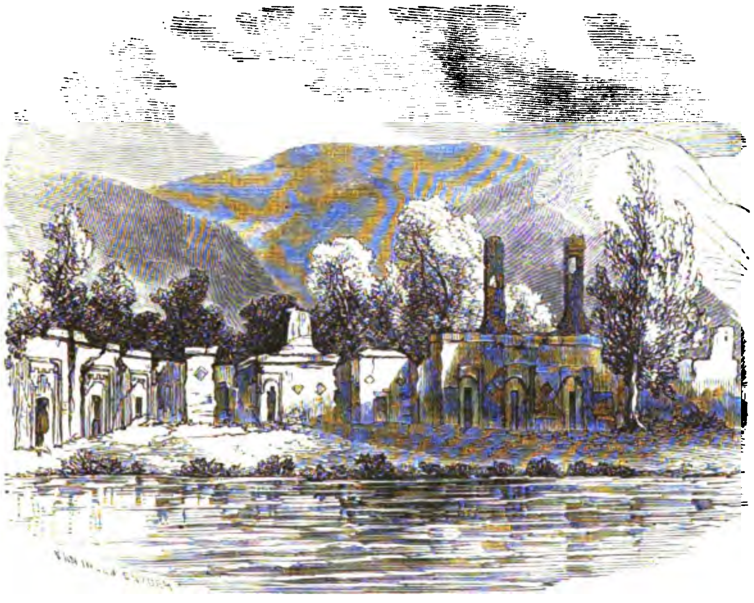
6. Describe the Mexican Plateau. Describe the passes that lead to the Gulf of Mexico. 7. Describe the table-land of Central America. 8. Describe the table-land of Colombia. 9. Describe the table-land of Ecuador. 10. Describe the table-land of Peru and Bolivia.

with flourishing cities and a hardy population, and is celebrated for its mineral wealth. Here Potosi is situated, famous for its silver, and said to be the highest city in the world, being 13,350 feet above the sea; while nearly at the same height, and containing 77,000 inhabitants, is the city of La Paz, bounded on the southeast by the snowy crests of the Illimani ranges, while the grand peak of Sorata, 21,286 feet high, rises in full view to the north.



CITY OF CUZCO.

But the most singular feature of this region is the beautiful Lake Titicaca, more than half the size of Lake Erie,—having an area of 4000 square miles. The lake is in some places 700 feet deep, and is studded with numerous islands, from the largest of which it takes its name. Here, according to the legends of the Peruvians, Manco Capac, the divine founder of their empire, first appeared; and the ruins of temples are still visible upon the sacred island of Titicaca.



RUINS OF TEMPLES ON THE ISLAND OF TITICACA.

The southern part of this basin is cold and sterile, but the hardier grains grow in the northern part; while around La Paz the olive and fig flourish, and magnificent vineyards abound.

Beyond the plateau of Titicaca, to the south, stretches a vast tract of desolate table-land called the Puna, which was also termed by the Spaniards Despoblado, or "uninhabited." It is a cold and barren region, swept throughout the year by piercing blasts from the icy summits of the Andes. No verdure gladdens its expansive levels, which are scantily covered with a yellowish grass; and only one plant—the *maca*, a tuberous root—is successfully cultivated in the sterile soil.

11. **Table-Land of Brazil.**—The plateaus of Eastern South America occupy more than half of the empire of Brazil, and comprise an area of 1,510,000 square miles, having a mean altitude of 3200 feet above the sea. The form of this vast region is that of a triangle, its base extending along the Atlantic from the Rio de la Plata on the south to within three degrees of the equator; while its northern limit stretches from the Falls of the Tocantins, in 3° 30′ south latitude, to the junction of the rivers Mamore and Beni, on the confines of Bolivia. At this point begins the southern boundary, which, following the direction of the Geral Mountains, strikes the Falls of the Parana, and thence extends to the Rio de la Plata, where it meets the southern extremity of the base.

According to Johnston, the greater part of this immense tract has an undulating surface, covered with dwarf trees and shrubs; but it embraces also extensive regions overshadowed by the dense foliage of mighty forests.

TABLE-LANDS OF THE EASTERN CONTINENT.

12. **Europe.**—Europe is almost destitute of plateaus, the only one of importance being that of the Spanish Peninsula, the interior of which is a lofty table-land, traversed by several mountain-ranges. Portions of this region are dreary and destitute of trees, while others are rich and productive, abounding with grains and fruits, the land increasing in fertility towards Portugal. This plateau has a general altitude of from 2000 to 3000 feet, and comprises an area of nearly 100,000 square miles. Upon this plateau stands Madrid, the capital of Spain, 2200 feet above the sea.

13. **Asia.**—The plateaus of Asia embrace a larger area than those of any other great division of the globe, and consist chiefly of six,—to wit, the Table-Lands of *Asia Minor and Armenia*, *Arabia*, *Persia*, *Central Asia*, *Thibet*, and *India*.

14. **Table-Land of Asia Minor and Armenia.**—This region, lying between the ranges of the Taurus and Anti-Taurus, is rugged and mountainous, and has an average altitude of 3280 feet above the sea. Its surface is diversified with numerous salt lakes, separated by fertile valleys. The land sinks in the central portions to a mean altitude of 2800 feet.

This table-land is prolonged eastward into Armenia between the Black Sea and the Caspian Sea, where it is the most elevated, rising to the height of 7000 feet. Yet it possesses a richer soil than the highlands of Asia Minor.

15. **Arabian Table-Land.**—Arabia comprises an area of about 1,200,000 square miles, the central portion of which is an elevated expanse from 5000 to 8000 feet above the sea, surrounded by deserts. According to the latest researches, made by Mr. Palgrave in the years 1862 and 1863, this central upland, about the size of the kingdom of France, is well watered and fertile, and enjoys an invigor-

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What is said respecting its population and mineral wealth? What is the most singular feature of this region? Give an account of Lake Titicaca. What of the climate and soil of this region? 11. Describe the table-land of Brazil. 12. What is said respecting the table-lands of Europe? Where is Madrid situated? 13. What is said respecting the plateaus of Asia? How many are there? Name them. 14. Describe the table-land of Asia Minor and Armenia.

ating climate. Within its limits "are the empire of Nedsjed, and the provinces of Kaseem and Djebel Shomer, which constitute one of the most delightful, if not absolutely the richest, regions of Asia." Its population is estimated at about 1,500,000.

16. **Table-Land of Persia.**—This region contains 350,000 square miles, and varies in height from 2000 to 3500 feet above the sea. It is bounded on the north by the Elborz Mountains, and, stretching westward, joins the plateau of Armenia. On the east rise the Suliman Mountains, where the plateau sinks to the valley of the Indus; while on the south and west it descends by slopes and terraces to the Arabian Sea and the Persian Gulf. The northern part is a vast salt desert, having an area of 27,000 square miles.

17. **Table-Land of Central Asia.**—This immense level, 3,800,000 square miles in extent, begins in about 70° east longitude, and, stretching in a northeasterly direction between the Kuen-Lun and Thian-Shan Mountains, is prolonged in the great Desert of Cobi to the river Amoor. Its length is estimated at 2000 miles, and its breadth is from 200 to 300 miles. The western portion of this table-land is a desolate tract, about 3000 feet above the sea, having a hard, gravelly soil, covered for the most part with rank, coarse grass, which furnishes pasture for the cattle belonging to the roaming tribes of Tartars.

The vast expanse of Cobi—which in the Mongolian language means a naked desert—is a rainless, sandy region, comprising an area of about 300,000 square miles, having a general elevation of 4300 feet. In the interior it sinks to the height of 2400 feet, but rises towards the east to the altitude of about 6000 feet. A valley traverses this desert from east to west, called the Shamo, or *Sea of Sand;* and west of this is the Han-Hai, or *Dry Sea,*—a great plain of shifting sand, rolled by the action of the wind into billows like the ocean. Only a few broken tracts of this expanse afford pasturage.

18. **Table-Land of Thibet.**—Between the Kuen-Lun and the Himalaya Mountains lies the table-land of Thibet, of an oval form, from 500 to 550 miles across, and containing an area of 166,000 square (geographical) miles. It is regarded as the highest inhabited region of the world, having, according to Sir John Herschel, the average altitude of 15,000 feet. Its western portion is 12,000 feet above the sea-level, and its eastern 17,000 feet. Here are the sacred lakes of Manasarowar and Rewan,—the former fifteen miles long and eleven broad, and 15,250 feet above the ocean. At the Niti Pass, by which these lakes are approached, are found the fossil remains of elephants and rhinoceroses, and other animals of the tertiary period, at an elevation of 17,000 feet above the sea.

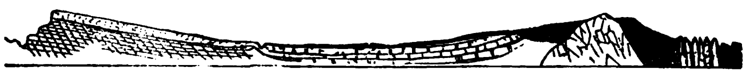
19. **Table-Land of India.**—This region, enclosed by the Vindhya Mountains and the Eastern and Western Ghauts, includes the table-land of Deccan and the plateau of Mysore. Rising from the high plains of Malwa, it stretches southward, increasing in altitude till it swells into the lofty uplands of the Neilgherries; while, like a huge mountain-wall, the Western Ghauts support it on the Malabar side, skirting the coast for the distance of 600 miles. The table-land of Deccan, on the north, has an altitude ranging from 1500 to 2500 feet; but the land to the south rises, in the plateau of Mysore, to heights varying from 4000 to 5000 feet above the sea.

20. **Africa.**—Africa has not been fully explored, and we are therefore but imperfectly acquainted with its physical peculiarities. We know, however, that Abyssinia is a lofty table-land, and that a large portion of South Africa is of the same character.

21. **Abyssinian Plateau.**—This consists of rolling expanses from 7000 to 8000 feet high, traversed by mountain-ranges and watered by numerous streams. Grains and grasses abound; and in many parts vast and dense forests cover the surface. The table-land descends abruptly in the direction of the Red Sea, but more gradually towards the Nile on the west.

22. **South African Table-Land.**—It appears from the late explorations of Dr. Livingstone that the central regions of South Africa form an elevated basin. The land rises both from the east and the west coast towards the interior to the altitude of from 4000 to 5000 feet above the sea, after which it dips inland, sinking at the centre to the height of about 2400 feet. Within these highlands vast lakes have recently been discovered.

This plateau, with its high mountain-ranges, appears to extend from the Cape of Good Hope to Abyssinia with only one break, through which the Zambezi flows to the Indian Ocean. It descends to the coast on the south and east by successive terraces, high mountain-ranges supporting this series of plateaus, which during the rainy season are clothed with verdure, but are parched and sterile throughout the rest of the year. At Cape Colony this table-land is said to be seven hundred miles broad.



SECTION OF SOUTH AFRICA, SHOWING THE CENTRAL BASIN.

23. In respect to the uses of table-lands, they possess advantages similar to those of the great mountain-ranges of the globe, and subserve the same ends.

CHAPTER V.

PLAINS.

1. **Plains** are extended regions, generally level, but diversified with hills and valleys. They rise but little above the sea, and in some places are even lower, but never exceed the altitude of 2000 feet,—all higher expanses being termed table-lands. Plains have received different names from their peculiarities. Thus, plains abounding in grass, but destitute of trees, are termed *Pampas, Llanos, Steppes,* and *Prairies;* those covered with forests, *Silvas;* and others, which in all seasons are dry and barren, are called *Deserts.*

PLAINS OF THE WESTERN CONTINENT.

2. The principal plains of the Western Continent are six in number,—namely, the *Great Central* and the *Atlantic Plain,* in North America, and the *Llanos of the Orinoco,* the *Silvas of the Amazon,* the *Pampas,* and the *Pacific Plain,* in South America.

North America.

3. **Great Central Plain.**—This immense expanse extends a distance of about 5000 miles from the Arctic Ocean to the Gulf of

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15. Describe the Arabian table-land. 16. Describe the table-land of Persia. 17. Describe the table-land of Central Asia. Describe the Desert of Cobi. 18. Give an account of the table-land of Thibet. 19. Describe the table-land of India. 20. What do we know of the physical features of Africa? What is said respecting its table-lands? 21. Describe the plateau of Abyssinia. 22. Give an account of the South African table-land. 23. What is said respecting the uses of table-lands?

What is the subject of Chapter V.? 1. What are plains? What different names are given to them, and why? 2. What is the number of the chief plains of the Western Continent? How many are there in North America? How many in South America? Name them.

Mexico,—the land rising from the northern shores to the sources of the Mississippi, and thence descending southward to the Gulf. It is bounded on the west by the Eastern plateau of the Rocky Mountains, while the chain of the Alleghanies, from the Cumberland to the Wotchish Mountains, constitutes its eastern limit. No part of this vast tract is elevated more than 1500 or 1600 feet above the sea, and a very large portion rises no higher than from 500 to 700 feet.

Near the sources of the Mississippi and Missouri the plain attains its greatest altitude, and, stretching in a belt of upland from the great lakes to the Rocky Mountains, forms an irregular watershed, dividing the Great Central Plain into two principal basins. These are the Basin of the Mississippi and the Hudson Bay Basin, including that of the St. Lawrence. The waters of the first flow into the Gulf of Mexico; those of the latter, into the Arctic Ocean and the bays and gulfs of the North Atlantic.

AN AMERICAN PRAIRIE.

The rich valley or basin of the Mississippi, throughout nearly its whole extent, is blessed with a salubrious climate and a soil of boundless fertility. Between the western slopes of the Alleghanies and the Mississippi, the Wabash, and Lake Michigan, nearly all the surface was once overspread by dense forests, many of which still remain; but westward the vast plain expands in a succession of gently undulating and verdant prairies, diversified with belts of woodland.

The Hudson Bay Basin, which almost rivals in size that of the Mississippi, lies north of a line extending from Labrador through the Wotchish Mountains to near Lake Itasca, and thence stretching northwesterly along the margin of the table-land at the base of the Rocky Mountains. It is a cold and dreary region, filled with swamps and lakes, and intersected by numerous streams. Its general elevation is about 500 feet; but portions of the border of this vast tract swell to the height of 1600 feet. The Laurentian Lake Basin, south of the Hudson Bay Basin, embraces the great northern lakes, whose surplus waters are discharged into the Atlantic by the noble river St. Lawrence.

4. **Atlantic Plain.**—From the Gulf of St. Lawrence to the Gulf of Mexico the Alleghanies gradually descend eastward to the Atlantic, forming a narrow belt of land, divided into an upper mountain-slope, and a lower expanse, called the Atlantic Plain.

This plain never rises higher than about 100 feet above the sea, and, from Long Island to beyond Cape Fear River, scarcely exceeds 50 feet in altitude. The land is for the most part sandy, but productive under good cultivation. In North and South Carolina, Georgia, and Florida, the coast-regions are much overflowed and are exceedingly swampy.

South America.

5. Passing southward, the lowlands of the Western Continent are continued in the immense plains of South America, which extend east of the Andes in three great divisions from Venezuela to Patagonia. These divisions are the *Llanos* of the Orinoco, the *Silvas* of the Amazon, and the *Pampas*. West of the Andes lies the *Pacific Plain*.

6. **Llanos of the Orinoco.**—This region, stretching from the Mountains of Caraccas to the mouth of the Orinoco, and thence southward to the equator, comprises an area of 160,000 square miles. It is almost perfectly level; for, according to Humboldt, within a space of 360 square miles there is not a single hillock a foot high. In other parts two kinds of inequalities exist: these are, banks of limestone or sandstone, extending for leagues, and forming level expanses four or five feet above the plain, and flat or rounded mounds a few yards in height.

This entire expanse is only about 192 feet above the sea, and is so flat that the motion of its rivers is hardly perceptible: the slightest wind contrary to the current of the Orinoco raises its waters and drives back its tributary streams. During the rainy season, vast tracts are flooded, and upon the subsiding of the water their surface is covered with a sea of verdure; but when the dry season returns, these beautiful plains are transformed into deserts, and nothing is seen of their former brilliant vegetation save where, on the borders of the streams and pools, clusters of Mauritia palms still display their bright and graceful foliage.

7. **Silvas of the Amazon.**—The interior of South America is an immense plain, situated on each side of the Amazon, and extending from the Andes to the Atlantic. It has an area of more than 2,000,000 square miles, and derives its name of *silvas*, or woods, from the vast unbroken forests which lie between the Amazon and the Orinoco, and cover an area of 700,000 square miles: the rest of this expanse consists of grassy plains and some hilly ranges.

The soil of the silvas is exceedingly rich, and clothed with an exuberance of vegetation that is truly marvellous. Stately trees, of which scarcely two of the same kind are found together, grow to the height of 180 or 200 feet, their leafy tops forming such a dense canopy of foliage that it is only here and there a narrow break reveals the clear blue sky. In many parts low shrubs cover the ground, vines and creepers trail from point to point, and huge, flexile climbing trees, twisted in strands like cables, and hanging in gigantic loops and coils, entwine the mighty trunks, and spread from tree to tree their living network, gemmed with thousands of gorgeous flowers. In other localities, according to Tschudi, "the colossal trunks stand alone. No shrub or flower springs from the slimy soil, where the rapidly-shooting mushroom finds genial nurture."

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3. Describe the Great Central Plain. What is said of the Basin of the Mississippi? What of the Hudson Bay Basin? 4. Describe the Atlantic Plain.

5. What is said respecting the plains of South America? 6. Describe the Llanos of the Orinoco. 7. Describe the Silvas of the Amazon.

8. **The Pampas.**—South of the Silvas are the Pampas, the third great level, comprising an area of 1,620,000 square miles, lying between the Andes and the Atlantic, and stretching from the Geral Mountains of Brazil to Terra del Fuego. Its length is estimated at more than 2000 miles, while its breadth ranges from 300 to 900 miles. It consists of two great divisions,—the Pampas of the Argentine Confederation and those of Patagonia. The former of these divisions embraces two expanses,—the *northern*, comprising the Pampas of Parana and a desert of sand, termed El Gran Chaco, and the *southern*, which, extending to the river Colorado, includes the Pampas of Buenos Ayres and Entre Rios.

SILVA IN BRAZIL.

The Pampas of Buenos Ayres are almost perfectly level, and have scarcely a stone upon their surface. They are destitute of trees, and have but little water; but during the wet season a rich verdure clothes the soil.

This immense tract is not, however, uniform in its character, but may be divided, excluding the Pampas of Patagonia, into *four* districts, differing in climate and productions. The first, stretching west of Buenos Ayres a distance of 180 miles, produces clover and thistles,—the latter of such enormous size as to form an impenetrable thicket, sometimes hundreds of square miles in extent.

To this succeeds a tract 430 miles broad, covered with luxuriant grass, affording abundant pasture for countless herds of wild cattle. Beyond this tract the plain sinks, forming the third region, about 1000 feet above the sea. Gathering in the waters of the Andes, it is wet and swampy, and abounds in extensive lakes and saline marshes,—the lagoon of Ybera being fifty miles long and twenty broad.

Immense portions of this plain are inundated by the annual rains, and multitudes of cattle perish by these floods. The drought that sometimes succeeds is equally fatal; for in the years 1830 and 1832 two millions of cattle died from want of food. The conflagrations that at times sweep through the dry grass of the pampas are likewise awfully destructive, thousands of cattle being involved in these seas of fire.

The fourth district is a rocky belt of land, bounded by a dense thicket of low trees skirting the base of the Andes.

Beyond the river Colorado are the Pampas of Patagonia, which extend southward to the extremity of that country,—a distance of about 800 miles. This region is desolate and sterile not only on account of its climate, but also from the nature of the soil, which consists of layers of basalt and loose, water-worn fragments of stone, interspersed with huge detached rocks or boulders. This rocky plain, intersected by a few streams and swept over by cold and blasting winds, yields but a scanty and blighted vegetation.

9. **Pacific Plain.**—On the western coast of South America the Andes slope down precipitously to the Pacific, forming a narrow belt of lowlands from 50 to 100 miles wide, reaching southward from Panama to the rocky coast of Patagonia. The northern and southern portions of this region are fertile; but the rest, lying between 3° 35′ and 30° south latitude, is a rainless district. Fruitful valleys here border the mountain-streams, which are separated by great sandy wastes. Such is the Desert of Atacama, in Bolivia.

PLAINS OF THE EASTERN CONTINENT.

EUROPE.

10. The greater portion of Europe consists of low, flat lands, which may be classed under two principal divisions,—viz.: the *Great Northern Plain* and the *Southern Plain*.

11. **Great Northern Plain.**—This region comprehends nearly two-thirds of Europe, and extends from the Pyrenees on the southwest to the Ural Mountains on the east. Its southern limit is the great mountain-zone which stretches through Europe into Asia; while the Arctic Ocean bounds it on the north, and the Atlantic, with its seas and bays, on the west.

It is divided into two parts, the *western* and the *eastern*. The *western* embraces the fertile plains of France, the rich, depressed levels of Belgium and Holland, and the fruitful tracts of the German lowlands, reaching through Prussia as far as the Vistula.

Fertile as this region is, it is interspersed with swamps and wide expanses of sterile soil. The river Prypet flows towards the Dnieper through a swamp having an area of 2000 square miles. The western coast of Denmark is one unbroken level of marshes; and a large part of Northern Germany, from Lower Silesia to Hanover, consists of barren wastes termed *landes*. These are sandy tracts, generally overgrown with pine, but in some places bare, or else covered with a species of heath. Similar sandy plains, intersected by swamps and meadows, are found in France at the base of the Pyrenees.

The *eastern* and much larger division, called the Sarmatian plain, lies between the Baltic and White Seas and the Black and Caspian Seas, extending eastward from the Vistula to the Ural Mountains.

That part of the plain which is north of the Valdai Hills is cold and unproductive, and much of the land is covered with a kind of moss, named *tundra*. The middle region, stretching from the Baltic to the Black Sea, is fertile and well watered, rich in grain, and especially in wheat. A part of its surface, millions of acres in extent, is covered with forests and deciduous trees. The rest of this great level to the south and east is of a varied character. One portion—the Steppes of Russia—is a vast treeless plain, hundreds of miles long, covered with rank, coarse grass. It has a rich, black soil, capable, when cultivated, of producing the wheat that now makes Russia the granary of the Levant. Thousands of mounds, or barrows,

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8. Describe the Pampas of South America. Describe the several great divisions of the Pampas. 9. Describe the Pacific Plain. 10. Of what does Europe chiefly consist? What are the names of its plains? 11. Describe the Great Northern Plain, and its several divisions.

—the sepulchres of the dead,—everywhere diversify its surface. Similar mounds are found throughout the steppes and vales of Tartary. The lowlands of Astrakhan are also fertile; but from the Caucasus, along the shores of the Black and the Caspian Sea, stretches a great saline plain abounding with salt lakes.

A BARROW IN A VALLEY OF THE TARBAGATAI MOUNTAINS, CHINESE TARTARY.—ATKINSON.

The Great Northern Plain is an almost unbroken level. From the Ural to the Carpathian Mountains—a distance of 1500 miles—there is scarcely an inequality in the surface: the greatest elevation is the Valdai Hills, ranging in altitude from 800 to 1100 feet. The average height of the plains of France is 480 feet. Were the ocean to rise 1000 feet, the whole plain, except the crest of the Valdai Hills, would be submerged, and Norway and Sweden would form an island.

12. **Southern Plain.**—The rest of the principal lowlands of Europe comprises the plains of Lombardy, of Hungary, and of the Lower Danube. Resting upon the Adriatic, and protected on the north by the Alps, the fruitful fields of Lombardy bloom like a garden, and abound in all the varied productions of a southern clime. The great levels of Hungary, termed *Puszta*, are a highly fertile tract, the soil consisting of rich black loam, interspersed with flats of deep sand. The districts of the Lower Danube are fertile, but swampy, and are especially productive on the banks of the streams.

PLAINS OF ASIA.

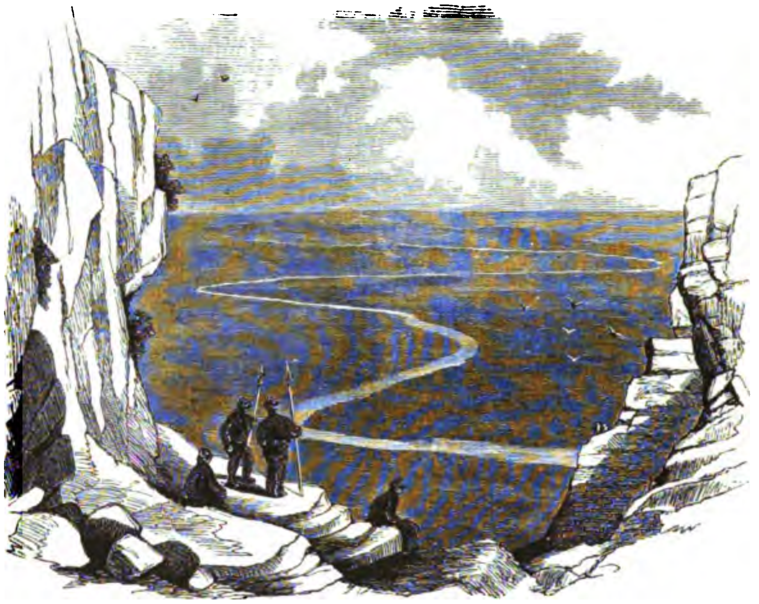
13. The Lowlands of Asia comprise the immense Steppes and Plain of Siberia, the Lowland of China, the Plains of Farther India, the Plain of Hindoostan, the Lowland of Turan, and the Lowland of Syria.

14. **Siberian Steppes and Plain.**—Passing southward of the Ural Mountains into Asia, the great northern level still extends eastward, embracing the Steppes of Kirguis, Ishim, and Baraba, and the vast Siberian Plain. The Siberian steppes constitute an immense expanse, traversed by sluggish streams, and never broken by a hill or a tree, but undulating like an ocean whose waves have been suddenly arrested. Stretching away from their mountain-boundaries for thousands of miles, these undulations succeed each other with such a sameness that the traveller can hardly recognize any progress by the change of scenery.

In the spring the steppes are covered with rich grass, which affords pasture for the numerous herds belonging to the Tartar hordes that roam over this region. Flowers also spring up in such masses that beds of mignonette, tulips, hyacinths, and crocuses cover the ground by acres. But the droughts of summer change these bright expanses into deserts, and the storms of winter turn them into snowy wastes.

Nothing can exceed the dreariness and desolation of the Siberian plain. The parallel of 62° north latitude is the limit of the grain-growing region, and beyond this the surface is covered with forests of fir and spruce, intermingled with swamps and lakes. The forests at last fail, and nothing exists but an immense expanse of morass, bog, and moss, called the Tundra, which extends to the shores of the Arctic Ocean.

The great northern levels of Europe and Asia are to be regarded as one immense plain, whose continuity is broken only by the Ural Mountains. Its area is estimated at not less than 4,500,000 square miles.



KIRGUIS STEPPES, FROM THE KARATOU MOUNTAINS.—ATKINSON.

15. **Lowland of China.**—China, famous for the antiquity of its civilization, its dense population, and the perfect culture of its soil, consists, in the eastern part, of an alluvial plain, more than 200,000 square miles in extent. This plain is extremely well irrigated, naturally and artificially; canals cross it in all directions, and it is cultivated like a garden. Rice is the principal production of the lowlands.

16. **Plains of Farther India.**—Between China and the Brahmaputra lies the Peninsula of Farther India, watered by noble rivers flowing through its entire length. The fine and rich soil constantly brought down by these streams has transformed the river-valleys into wide and fertile plains. The Birmese Empire, equal to France in size, extends over the plains of the Irrawaddy; and in Cambodia are immense tracts of alluvial soil, clothed with all the prodigality of vegetation which marks a tropical clime.

What is said of the Steppes of Russia? What is said respecting the surface and elevation of the Great Northern Plain? 12. Describe the Southern Plain. 13. Mention the plains of Asia. 14. Describe the Steppes and Plain of Siberia.

In what light are the great northern levels of Europe and Asia to be regarded? 15. Describe the Lowland of China. 16. Describe the Plains of Farther India.

17. **Plain of Hindoostan.**—The Plain of Hindoostan stretches southward about 1500 miles from the base of the Himalayas to Deccan, and westward from the Ganges to the Indus, with a breadth ranging from 300 to 400 miles. This region, renowned as the seat of mighty empires and the abode of a singular and cultivated people, possesses a wondrous fertility. No other country, except China, can vie with it in the fruitfulness of its soil; and it enjoys a great variety of climate, from the genial temperature of Southern Europe to the extreme heat of the tropics.

The finest portion of this plain is the alluvial region watered and fertilized by the majestic Ganges and its tributaries. The lower part of this splendid tract is the richest, and produces abundance of rice, sugar, cotton, indigo, and opium, and every kind of tropical fruit. In the upper section, wheat and other bread-grains are cultivated. The Valley of the Indus occupies the western division of the Plain of Hindoostan. It is a sandy tract, but fertile when irrigated. Towards the sea it expands into a sterile level, called the Thur, the southern portions of which are so low as to be overflowed by the tide.

18. **Lowland of Turan.**—This region extends from the Elborz Mountains to the Kirguis Steppes, and embraces the vast depressed area of the Caspian and the Aral Sea.

19. **Lowland of Syria.**—This level stretches southward through Mesopotamia to the Persian Gulf. In the southern part it is dry and stony; but around the lower courses of the Tigris and the Euphrates the soil is rich and productive. In the north the land is sterile; though beautiful valleys, like those of Damascus, are found set like gems in the surrounding wastes.

North of the table-land of Arabia lies the Great Syrian Desert, which, according to Mr. Palgrave, is an immense ocean of loose, reddish sand, heaped up in enormous ridges running parallel to each other from north to south, and ranging from 200 to 300 feet in height. Standing on their crests, the traveller looks down on what seems a vast sea of fire rolling beneath a violent wind.

Between the Lebanon and Anti-Lebanon ranges, in the north of Palestine, spreads out the Valley of Bekka,—a fertile and well-watered tract.

AFRICA.

20. The plains of Africa include the Great African Desert, or the Sahara, and the Central Plain.

21. **The Sahara.**—The Great African Desert is a vast barren tract extending eastward from the shores of the Atlantic to the Valley of the Nile,—a distance of about 3000 miles,—and lying between Soudan on the south and the grassy slopes of the Atlas Mountains on the north, having a breadth varying from 700 to 1200 miles. The area of this great expanse has been estimated at 2,700,000 square miles. Some portions on the north have been supposed to be below the sea-level; while others rise above the plain in broad plateaus whose elevation ranges from 1000 to 1500 feet.

The surface of the Sahara possesses a varied character. Immense portions are burning wastes of shifting sands, without water and vegetation; others are gravelly and saline, interspersed with low, bare rocks, and producing a growth of small shrubs and coarse grass. But this dreary region is otherwise diversified; for wherever water rises to the surface, verdant islands, termed *oases*, occur, blooming amid the surrounding desolation. Such are the oases of Tibesty, Air, and Fezzan. Fezzan, which is one of the largest oases, contains 100,000 inhabitants, whose principal food is derived from the forests of the date and palm with which this region abounds. The surface of the oasis is generally below that of the surrounding desert.

The Nubian Desert may be regarded as prolonging the plain of the Sahara to the Red Sea, since these desolate wastes are separated only by the Valley of the Nile, which, for a thousand miles, borders the desert on either side with its brilliant verdure. The Sahara is, indeed, the western division of an immense desert zone, which stretches from the Atlantic to Egypt, and is thence continued north-easterly through Arabia, Persia, and Tartary, ending in the Desert of Cobi.

22. **The Central Plain.**—It has been seen that the southern portion of Africa is a plateau. From the northern boundary of this plateau the surface descends towards the Mediterranean, forming the Sahara. But the descending land does not change at once into a desert; for the waters that flow from the table-land towards the north fertilize a large tract of country, stretching across Africa in its greatest breadth, and bounded by the southern limit of the desert and the northern line of the table-land.

This region, which includes Soudan, embraces vast levels, some of which are fertile and well cultivated; while others are sandy wastes, interspersed with salt lakes, and having quarries of rock-salt, which are the riches of the country. Large and thriving kingdoms are here found, such as Bornou and Houssan,—the former of which occupies a noble plain two hundred miles long and nearly as many broad.

In Senegambia and Guinea a rich alluvial belt of lowland extends along the sea-coast, wonderfully productive, but possessed of a deadly climate.

23. **Australia.**—Only one-fifth of this great island has been fully explored; but from the partial researches made by various travellers, especially by Sturt, Mitchell, and Kennedy, there is very little doubt that the interior is an immense desert.

In the years 1844–46, Captain Sturt penetrated to the centre of the island, and his observations prove that Central Australia is another Sahara. It is a desolate, stony region, depressed in some places below the level of the sea. During the rainy season extensive saline marshes are formed, which become in the summer parched and sterile tracts, where no life exists. Over this desert sweep hot and blasting winds, as fierce in their intense heat as the African simoom. To the north the land improves; and in South Australia there is every diversity of soil and surface.

24. **Plains—Their Relation to Civilization.**—The river-plains have ever been the chosen seats of settled industry and civilization. The plains of China, Hindoostan, Egypt, and Mesopotamia were the populous abodes of mankind in the early history of the world; and as in former ages, so now the principal sites and centres of industry and opulence are found in the river-plains of both continents, since these regions possess special adaptations and facilities for agriculture, commerce, and the arts. But the vast steppes of the North have ever been the abode of fierce nomadic races, whose hordes, lured by the wealth and rich products of more favored climes, have again and again overrun the southern plains, infusing fresh life and new ideas of freedom into the effeminate and effete nations with whom they mingled.

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17. Describe the Plain of Hindoostan. Where is the Valley of the Indus? 18. Describe the Lowland of Turan. 19. Describe the Lowland of Syria. 20. What are the plains of Africa? 21. Describe the Sahara. What is said of the oasis of Fezzan? What of the Nubian Desert? 22. Describe the Central Plain of Africa. 23. Give an account of the lowland of Australia. 24. What is said of plains in reference to human progress?

REVIEW AND MAP QUESTIONS ON THE CONTOUR AND RELIEF OF THE LAND.

CONTINENTS.

How are the two great continents designated?
What other masses of land are found in the high northern and southern latitudes?
What great island is there which is sometimes called a continent, and where is it situated?
Which continent extends farthest to the south?
Which to the north?
Which is the larger of the two continents?
Between what parallels of latitude does the Eastern Continent lie?
Between what meridians?
In what direction does it extend in its greatest length?
What is its area?
What are its grand divisions?
How are these situated in reference to the equator?
Which is the largest division?
Which is the smallest?
What is the area of the Western Continent?
In what direction does it run in its greatest length?
Between what parallels of latitude does it lie?
Between what meridians?
Which of the great divisions of the land has the most extensive coast-line compared with its area?
Which the least?
What form do the great masses of land generally assume towards the south?
In what regions are the continents broadest?
Is this true of their divisions?
Are both the continents nearly divided by the sea?
What cluster of islands near the Western Continent corresponds to the Asiatic Archipelago near the Eastern Continent?

ISLANDS.

Point out on the map instances of continental islands in the different oceans and seas.
What are oceanic islands?
In what ocean are they most numerous?
Trace on the map the great chain that exists in the Pacific Ocean.
Point out the three great belts of volcanic islands.
Which is the most northerly volcanic island?
What is its latitude?
Point out the volcanic islands of the Atlantic Ocean.
Where have volcanic islands been recently formed?
What is the nature of the Aleutian Islands?
Within what limits are coral islands found?
In what ocean do they abound?
Point out the most remarkable groups of atolls.
Where do we find encircling reefs?
Where are the most remarkable barrier reefs situated?
Which is the largest island?
What is its extent?
To what class do the largest islands belong, oceanic or continental? *Show by the map.*
In what form do islands usually occur?
Point out some of the most remarkable groups.
Where are the most noted solitary islands situated?

MOUNTAINS.

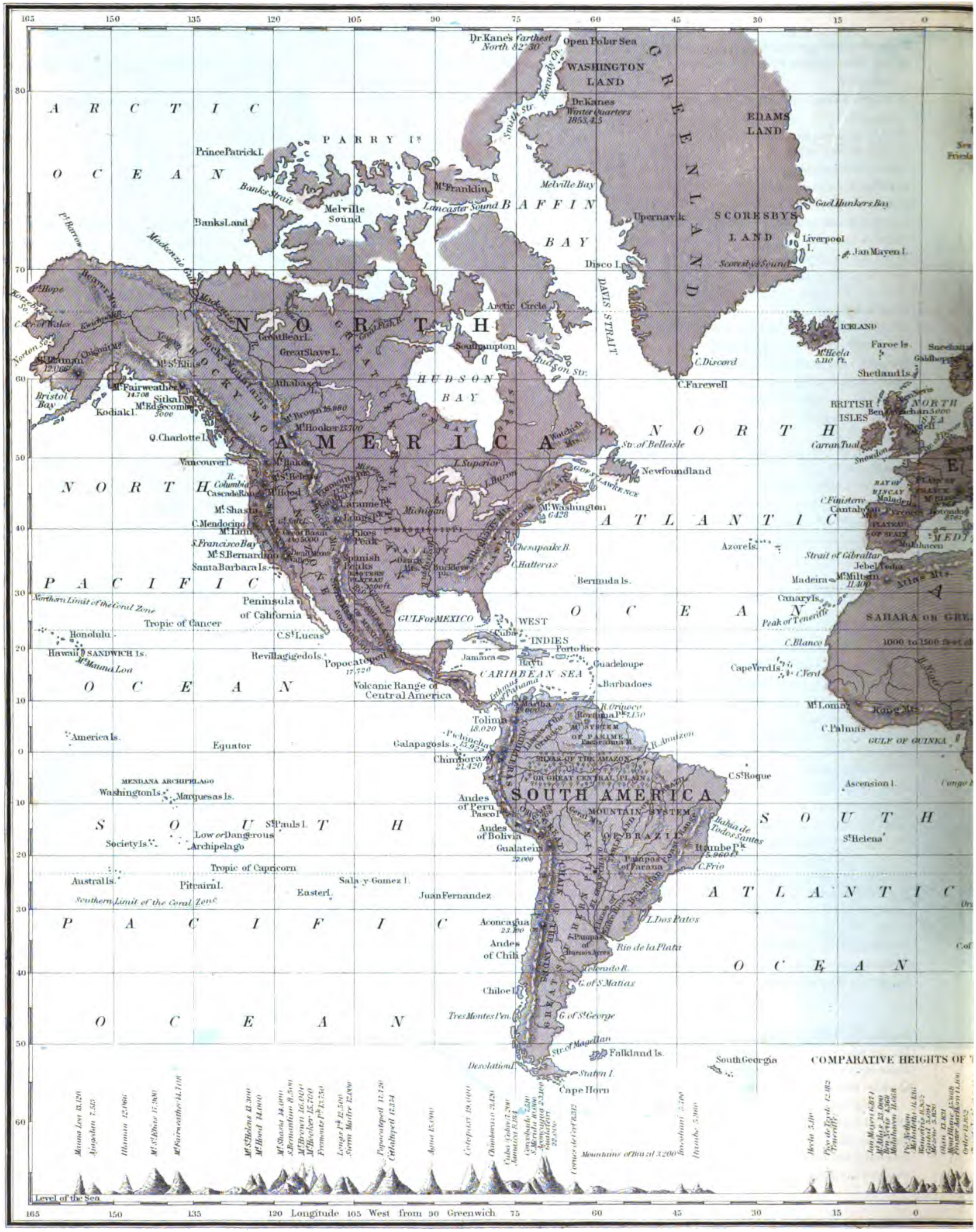
Show in what direction the mountain-chains of a continent usually run.
Do the minor mountain-ranges of a peninsula follow a similar law?
Point out on the map instances of these in both continents.
On what side are the mountain-slopes most abrupt, in the several grand divisions of the globe?
Which of the two continents has the largest chain?
Show that the highest mountains of a continent face the largest ocean.
Name the mountain-systems of North America.
Describe the Rocky Mountain system.
Describe the Alleghany system.
Name the South American systems.
Describe the Andes.
Between what parallels of latitude are the Rocky Mountain and the Andean chains included?
Trace the great mountain-zone of the Eastern Continent from Gibraltar to Behring Strait.
Mention the mountain-systems of Europe.
What mountains separate Europe and Asia?
Where is the Caucasian range?
Name the mountain-systems of Asia.
Which is the grandest?
Describe the maze of mountain-chains in Eastern and Northeastern Asia.
What important ranges are north of the Hindoo Koosh?
What are the mountain-systems of Africa?
Which is the highest?
Where are the Atlas, Cameroons, and Kong Mountains situated?
What high range is in Eastern Africa?
What island east of Africa has a great range of mountains?
What mountains are found in Australia?
How are they situated?
State the height of the chief mountains above the sea-level in the continents and islands of the globe.
Which is the highest mountain on the globe?
Point out on the map the chief regions below the sea-level.

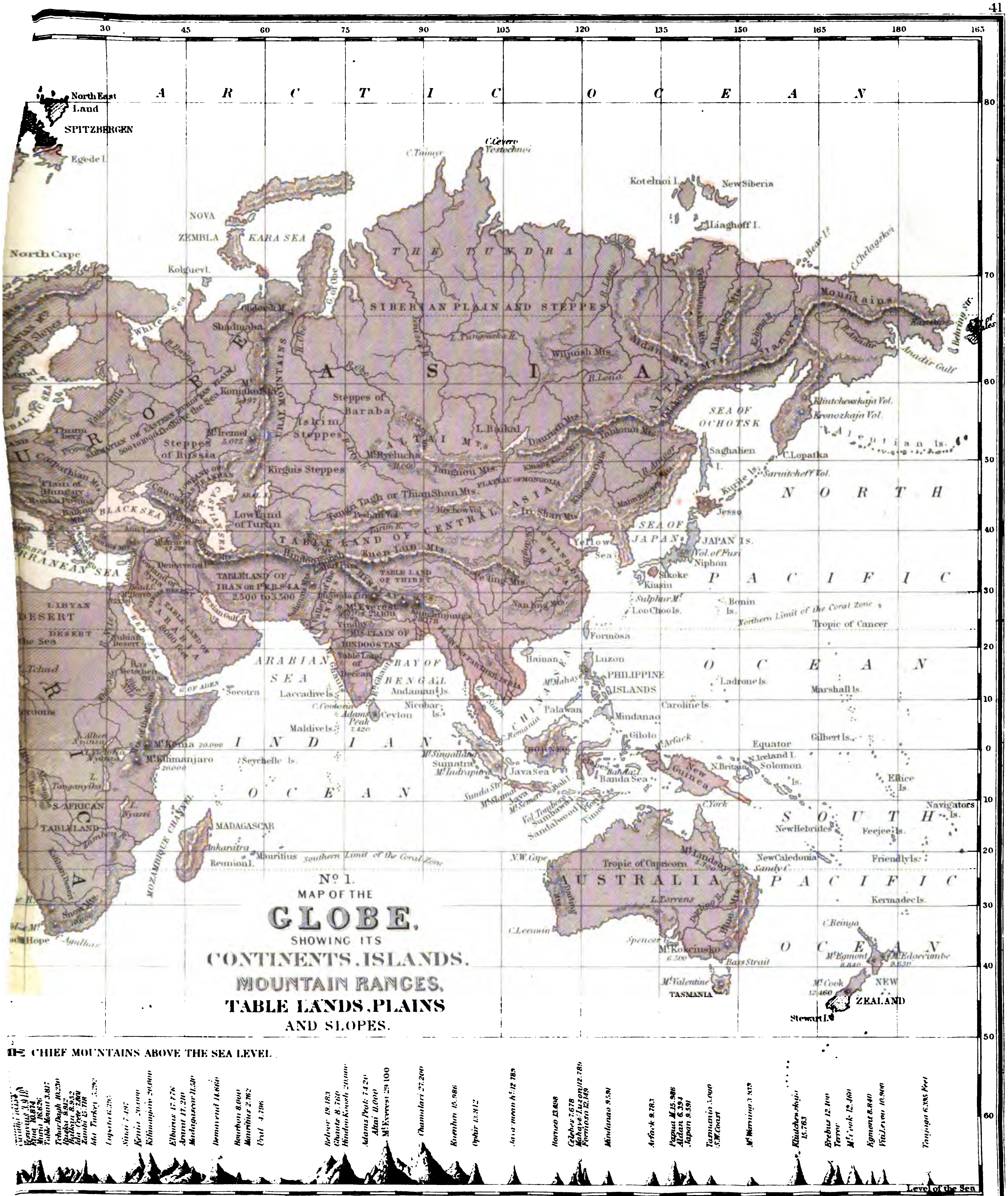
TABLE-LANDS, OR PLATEAUS.

Which of the two continents is most remarkable for its plateaus?
Name the plateaus or table-lands of North America.
Where are they situated?
What is the height of the table-land of Mexico?
Name the plateaus of South America.
Which is the loftiest?
What plateau is found in Europe?
Name the table-lands of Asia, and describe them.
Which is the largest?
Which is the highest?
Which continent has the highest plateau?
Name the plateaus of Africa, and describe them.

PLAINS.

Which continent is distinguished for its plains?
Name the plains of North America.
Which is the larger?
Give an account of it in respect to extent, soil, and climate.
Describe the Atlantic Plain.
Mention the plains of South America.
Where are the Llanos situated?
What is their character?
Describe the Silvas.
Why are they so called?
Describe the Great Southern Plain, or Pampas.
What is the nature of the several tracts that compose it?
Mention the plains of Europe.
What are the divisions of the Great Northern Plain?
What is the height of the eastern European Plain?
Where are the Steppes of Russia?
Where is the plain of Hungary?
Name the plains of Asia.
Describe the Siberian Plain and Steppes.
Point out the position of the remaining plains of Asia, and describe them.
What plains has Africa?
Where is the Great Desert.
What is the nature of its soil?
Where is the Nubian Desert?
What is its altitude above the sea?
Point out the several positions of the other African plains, and describe them.


ARCTIC OCEAN
NORTH PACIFIC OCEAN
SOUTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
NORTH AMERICA
SOUTH AMERICA
GREENLAND
Dr. Kane's Farthest North 82° 30'
Open Polar Sea
WASHINGTON LAND
Kennedy Ch.
Smith Str.
Dr. Kane's Winter Quarters 1853, 4, 5
EDAMS LAND
PARRY Is
Prince Patrick I.
Banks Strait
Banks Land
Melville Sound
Mt. Franklin
Lancaster Sound
BAFFIN BAY
Melville Bay
Upernavik
SCORESBYS LAND
Scoresbys Sound
Gael Hamkers Bay
Liverpool I.
Jan Mayen I.
Disco I.
DAVIS STRAIT
Arctic Circle
Pt. Barrow
Mackenzie Gulf
Mackenzie R.
C. Pt. Hope
Kotzebue Sd.
C. Pr. of Wales
Norton Sd.
Mt. St. Elias
Mt. Fairweather 14,708
Sitka
Mt. Edgecombe 3000
Kodiak I.
Bristol Bay
Great Bear L.
Great Slave L.
Athabasca L.
Southampton I.
Hudson Str.
HUDSON BAY
ROCKY MOUNTAINS
Mt. Brown 16,000
Mt. Hooker 15,700
Q. Charlotte I.
Vancouver I.
R. Columbia
Cascade Range
Mt. Baker
Mt. St. Helens
Mt. Hood
Mt. Shasta
C. Mendocino
S. Francisco Bay
Mt. S. Bernardino
Santa Barbara Is.
Fremont's Pk.
Laramie Pk.
Pikes Peak
Spanish Peaks
Great Basin
Ozark Mts.
Mississippi R.
Missouri R.
L. Superior
L. Huron
Michigan
Mt. Washington 6428
Alleghany Mts.
Chesapeake B.
C. Hatteras
Watchish Mts.
Str. of Belleisle
Newfoundland
Gulf of St. Lawrence
C. Farewell
C. Discord
ICELAND
Mt. Hecla 5,110 ft.
Faroe Is.
Shetland Is.
BRITISH ISLES
Ben Nevis
Carran Tual
Snowdon
Bay of Biscay
C. Finisterre
Cantabrian Mts.
Strait of Gibraltar
Jebel Tedla
Mt. Miltsin 11,400
Atlas Mts.
Madeira
Canary Is.
Peak of Teneriffe
C. Blanco
SAHARA OR GREAT
1000 to 1500 feet
Cape Verd Is.
C. Verd
Mt. Loma
Kong Mts.
C. Palmas
GULF OF GUINEA
Ascension I.
St. Helena
Azore Is.
Bermuda Is.
Peninsula of California
Tropic of Cancer
C. St. Lucas
Revillagigedo Is.
Popocatepetl 17,720
GULF OF MEXICO
WEST INDIES
Cuba
Jamaica
Hayti
Porto Rico
Guadeloupe
Barbadoes
CARIBBEAN SEA
Isthmus of Panama
Volcanic Range of Central America
Honolulu
Hawaii
SANDWICH Is.
Mt. Mauna Loa
Northern Limit of the Coral Zone
America Is.
Equator
MENDANA ARCHIPELAGO
Washington Is.
Marquesas Is.
St. Pauls I.
Society Is.
Low or Dangerous Archipelago
Tropic of Capricorn
Austral Is.
Pitcairn I.
Easter I.
Sala y Gomez I.
Juan Fernandez
Southern Limit of the Coral Zone
Galapagos Is.
Tolima 18,020
Pichincha 15,922
Chimborazo 21,420
R. Orinoco
Roraima Pk. 7,150
MT. SYSTEM OF PARIME
R. Amazon
SELVAS OF THE AMAZON
GREAT CENTRAL PLAIN
MOUNTAIN SYSTEM OF BRAZIL
C. St. Roque
Bahia de Todos Santos
Itambe Pk. 5,960
C. Frio
Andes of Peru
Pasco
Andes of Bolivia
Gualatieri 22,000
Pampas of Parana
GREAT CHAIN OF THE ANDES
Aconcagua 23,100
Andes of Chili
Pampas of Buenos Ayres
L. Dos Patos
Rio de la Plata
Colorado R.
G. of S. Matias
Chiloe I.
Tres Montes Pen.
G. of St. George
Str. of Magellan
Falkland Is.
Desolation I.
Staten I.
Cape Horn
South Georgia
COMPARATIVE HEIGHTS OF
Mauna Loa 13,120
Ajagshin 7,513
Illiamna 12,066
Mt. St. Elias 17,900
Mt. Fairweather 14,708
Mt. St. Helens 13,300
Mt. Hood 14,000
Mt. Shasta 14,000
S. Bernardino 8,500
Mt. Brown 16,000
Mt. Hooker 15,700
Fremont's Pk. 13,750
Longs Pk. 12,500
Sierra Madre 12,000
Popocatepetl 17,720
Citlaltepetl 17,374
Agua 15,000
Cotopaxi 19,000
Chimborazo 21,420
Cuba 7,200
Jamaica 8,184
Corcovado 7,510
S. Merida 15,000
Aconcagua 23,100
Gualatieri 22,000
Cerro de Cerf 8,312
Mountains of Brazil 3,200
Bandeira 5,700
Itambe 5,960
Hecla 5,110
Pic de Teyde 12,182
Jan Mayen 6,874
Mt. Atlas 13,000
Ben Nevis 4,368
Mulahacen 11,658
Level of the Sea
Longitude West from Greenwich
165 150 135 120 105 90 75 60 45 30 15 0
80 70 60 50 40 30 20 10 0 10 20 30 40 50 60



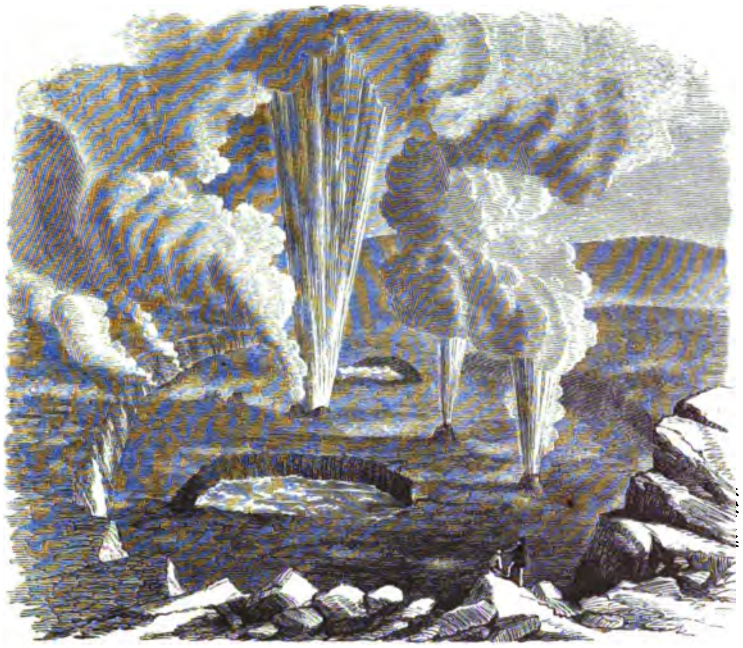
Nº 1.
MAP OF THE GLOBE,
SHOWING ITS CONTINENTS, ISLANDS, MOUNTAIN RANGES, TABLE LANDS, PLAINS AND SLOPES.

Engraved by J. M. Atwood Philadelphia

CHAPTER VI.

VOLCANOES.

1. **A Volcano** is a mountain which emits from its summit or sides fire and smoke, and, at varying intervals, ejects stones, ashes, and floods of molten minerals, termed *lava.* The upper part is a cone formed by the ejected matter, and terminating in a hollow bowl-shaped cavity, called a crater, from which the lava issues: the size of the crater has no relation to that of the volcanic mountain. In some cases craters are depressions in lofty table-lands.


KILAUEA, HAWAII.

2. **Crater.**—The walls of the crater are not unfrequently entire, but they are generally rent by immense fissures, through which the floor of the crater can be reached. This floor, in active volcanoes, is the seat of their energy.

In the volcano of Kilauea in Hawaii, one of the most remarkable in the world, the great crater is a vast depression in a plateau nearly 4000 feet above the sea. It is seven and a half miles in circumference, three long, and one broad, and sinks more than 1000 feet below the plain. The volcanic action is concentrated in a space about two miles long, occupied by numerous smoking cones and lakes of lava.

When the crater was visited by Mr. Ellis in 1823, he observed two lava-lakes, the largest of which was 1190 yards long. Eleven years afterwards they were still in existence, and presented to Mr. Douglas the appearance of vast caldrons of lava in furious ebullition, sometimes spouting to the height of seventy feet; while the burning flood, rolling onward like a river beneath a fiery arch, plunged down and was lost in a deep abyss.

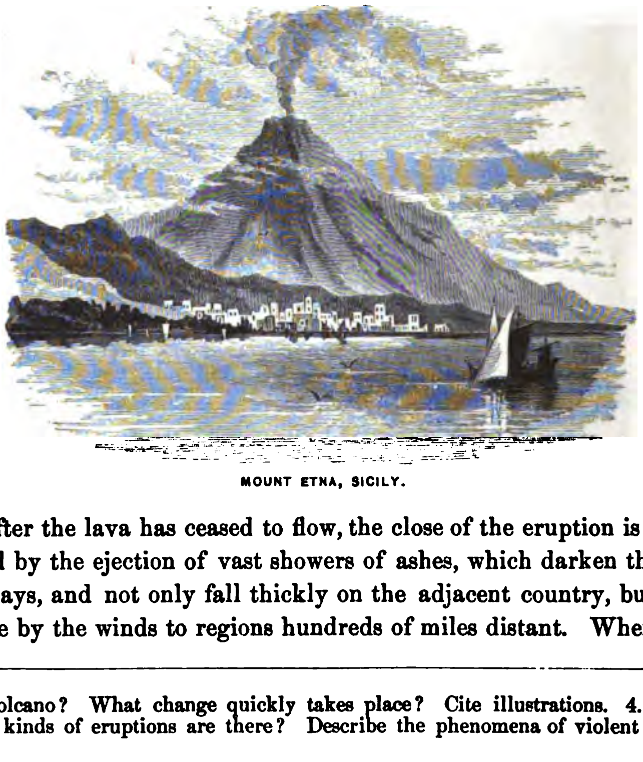
3. **Volcanic Products.**—Lava varies much in its composition and structure. It is chiefly composed of a few minerals; but nearly a hundred ingredients have been discovered in the lavas of Vesuvius.

In 1845, Professor Ehrenberg ascertained that volcanic products abound with the flinty shells of minute microscopic animals. The structure of lava depends mainly upon the pressure under which it is cooled: where this is great, a firm and compact mass is formed; but if the lava is subjected to but little pressure, and is inflated with the gas, it is light and porous, forming scoriæ and pumice-stone.

The spray of the lava, driven and cooled by the wind, spins out into fine, delicate threads. These are found in great abundance at Kilauea, and are called by the natives the "hair of Pelĕ," from the name of the fabulous divinity of the volcano.

When the lava first issues from the crater, it is a viscid fluid like tar; but it quickly cools at the surface, and, being a bad conductor of heat, a firm crust is soon formed, under which the burning stream flows on a few inches below. In 1794, during an eruption of Vesuvius, the inhabitants of Torre del Greco, twelve hours after their town had been overwhelmed by a flood of lava, returned to their homes over the lava-crust which bridged the fiery stream beneath them. A mass of lava, ejected in 1759, at Jorullo in Mexico, was found by Humboldt, in 1804, to be still hot enough to light a cigar within the cracks of its surface; and smoke was seen by Burckhardt to issue from it in 1827.

4. **Eruptions.**—Eruptions are of *two kinds,*—those that are violent, and those that are not. Violent eruptions are usually preceded by low, subterranean noises, which are followed by loud explosions and earthquakes. Clouds of smoke then rise in dense columns to the skies, mingled with vapors and deadly gases, and often with streams of burning sand. In the midst of these dark clouds forked lightnings play, and globes of fire burst like bomb-shells. Next follows a discharge of red-hot stones and the outpouring of the lava-flood. The lava, in escaping, either flows over the edge of the crater, or bursts through its sides, the latter mode being the usual one; for its rocky walls, thick as they are, are at times unable to withstand the enormous pressure of the fluid mass and the expansive force of its confined gases and vapors. It is stated by Dolomieu that *nine-tenths* of all the lava-eruptions of Etna have been from its sides.


MOUNT ETNA, SICILY.

After the lava has ceased to flow, the close of the eruption is indicated by the ejection of vast showers of ashes, which darken the air for days, and not only fall thickly on the adjacent country, but are borne by the winds to regions hundreds of miles distant. When the

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What is the subject of Chapter VI.? 1. Define a volcano. 2. Describe the crater. Give an account of the volcano of Kilauea. 3. Give an account of volcanic products. What is the appearance of lava when it first issues from the volcano? What change quickly takes place? Cite illustrations. 4. How many kinds of eruptions are there? Describe the phenomena of violent eruptions.

volcano rises above the limit of constant frost, the approach of an eruption is shown by the sudden melting of the snow and ice that clothe its summit, and which gives rise to rapid and destructive torrents.

Many of these phenomena were strikingly displayed during the eruption of the Souffrière Mountain, in the island of St. Vincent, in the West Indies, which occurred in April, 1812. On the 27th of this month the volcano burst forth, showering down sand and dust; and three days afterwards, streams of glowing lava, flowing from beneath a pyramid of flame, poured down the sides of the mountain in torrents to the sea. Red-hot stones and ashes rained down for hours, and, earthquake following earthquake almost incessantly, the whole island undulated like water shaken in a bowl.

The next day the atmosphere was clouded with ashes, and to such an extent that the deck of a vessel five hundred miles from St. Vincent was covered with volcanic dust to the depth of five inches.

The eruptions which occurred between the beginning of September and the middle of November, 1866, in the vicinity of the islands of Tau and Olosenga, which belong to the group of Navigators Islands, were characterized by similar phenomena, and by others also of a peculiar nature.

A few days previous to the 12th of September, 1866, subterranean noises were heard and earthquakes were frequent. At noon on this day there was an unusual commotion in the sea at a point one mile and a half from Olosenga and three from Tau; and on the next morning the volcanic action was unmistakable. From the 16th to the 19th there was one continued succession of eruptions,—jets of mud and dense columns of volcanic matter rising in terrific grandeur two thousand feet above the level of the sea, and spreading out in vast clouds of dust.

The roar of the eruptions, the crash and collision of masses of rock met in their downward course by others flying up, were fearful. The sea boiled furiously within a circuit half a mile in diameter, and heaps of dead fish were washed ashore,—among them deep-sea monsters, from six to ten feet long, such as were never before seen by the natives. The heated atmosphere for miles around was filled with ashes, smoke, and sulphurous vapors. After the 19th the violent action began to abate.

The other kind of eruptions are unattended by earthquakes, or by the slightest tremor of the ground; neither is there any ejection of mineral masses, the tremendous forces involved in this phenomenon acting with silent power. The crater, in volcanoes of this kind, gradually fills with lava, which either overflows its rim or bursts through the sides,—the stream continuing to flow until the force which raised it is expended.

The volcanoes of Mauna Loa and Kilauea, in Hawaii, are remarkable instances of this kind. Mauna Loa is situated 13,760 feet above the sea and 9790 feet above Kilauea, sixteen miles distant. Its crater is 13,000 feet long, 8000 feet wide, and about 800 feet deep. In 1843 this immense basin was filled up with lava to such an extent that it broke through the mountain at the height of 12,000 feet, and poured in fiery torrents down its sides, levelling the forest in its course.

As the flood spread out and cooled, a crust was formed on the surface, beneath which rushed the burning river at the rate of from ten to fifteen miles an hour. The lava-stream extended a distance of sixty-five miles, and was from one to ten miles wide, while its depth ranged from ten to three hundred feet. No earthquake or showers of ashes and cinders attended this eruption.

During the three grand eruptions of Kilauea in 1823, 1832, and 1840, no violent phenomena occurred; but its vast crater was silently filled up with lava to the depth of 400 or 500 feet before it escaped from its enclosing walls.

In the eruption of 1840 the main stream of the lava burst from the earth at a point twenty-seven miles from the crater, and twelve miles from the sea, towards which it flowed. The width of the stream varied from one to four miles; and when it reached the sea it poured over a precipice fifty feet high, in a fiery cataract half a mile broad.

"The burning lava," says Mr. Coan, "on reaching the water was shivered like glass into millions of particles, which rose in clouds, darkened the sky, and fell like a storm of hail on the surrounding country. Vast clouds of steam and vapor rolled off before the wind, and the reflected glare from the lava formed a fiery firmament overhead. For three weeks this terrific river flowed with little abatement; night was converted into day over all eastern Hawaii; and at the distance of forty miles fine print could be read at midnight."

5. **Volcanic Force.**—The tremendous energy displayed by volcanoes is shown by the great height to which huge masses of rock are thrown, and also by the immense amount of matter ejected. According to Sir William Hamilton, stones were hurled by Vesuvius, in the great eruption of 1779, to the height of 2000 feet, and a mass of rock was ejected having a thickness of 17 feet and a circumference of 108 feet. During an eruption of Teneriffe, stones were projected to altitudes varying from 2600 to 3600 feet. The heights in such cases are determined by noting the time occupied by the masses in falling. But these instances of projectile forces are far exceeded by the might of the volcano of Cotopaxi, which is said to have hurled a rock 300 cubic feet in size to the distance of nine miles.

COTOPAXI, SOUTH AMERICA.

The amount of matter ejected is enormous. During the eruption of Kilauea in 1823, 27,000,000,000 cubic feet of matter is computed to have been ejected,—sufficient to form a conical mountain 3000 feet high having a base 3400 feet in diameter. But the greatest lava-flood on record is that which, in 1783, burst from Skaptar Jökul

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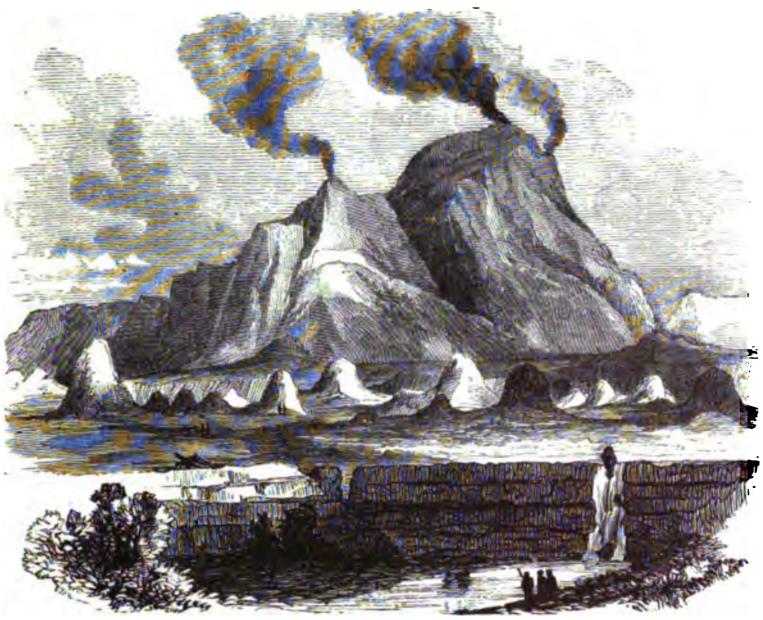
Describe the eruption of the Souffrière Mountain. Give an account of the volcanic eruptions in the vicinity of Olosenga and Tau. What are the phenomena of volcanic eruptions which are unattended by violence? Describe the eruptions of Mauna Loa and Kilauea. 5. What facts display the force of volcanoes? Cite the instances given of volcanic force. What is said respecting the amount of ejected matter?

in Iceland, and continued to flow for two years. It formed two principal rivers, which flowed in nearly opposite directions, one being fifty miles long and twelve broad, and the other forty miles long and seven broad. Wide river-beds were filled up to the depth of from 400 to 600 feet, and lava-lakes were formed 100 feet deep and from twelve to fifteen miles wide. The amount of matter thus ejected is computed at 40,000,000,000 of tons,—a mass which, accumulated, would cover London with a mountain rivalling in size the Peak of Teneriffe.


JORULLO, MEXICO.

The quantity of volcanic sand and ashes which is thrown out during eruptions is almost incredible. The beautiful cities of Herculaneum and Pompeii were completely buried by the showers of ashes ejected by Vesuvius in the year 79. During the fearful eruption of Tomboro in the island of Sumbawa, which occurred in 1815, such clouds of sand and ashes were ejected that houses forty miles distant were crushed beneath them. At Macassar, 250 miles from Sumbawa, ashes fell to the depth of one and a half inches, and total darkness prevailed after sunrise.

The volcanic dust was carried even as far as Amboyna, 800 miles distant from the volcano. Near Sumbawa, cinders, scoriæ, and ashes fell into the sea in such quantities that they formed a crust upon its surface, and for miles around the island the ocean was so covered with this floating matter that the progress of ships was materially impeded.

But the energy of volcanic action is most strikingly displayed in the upheaval of mountains, the formation of new islands, and the elevation of coasts. The mountain of Jorullo, in Mexico, is a result of volcanic power, and its formation is thus described by Humboldt:—

"On the night of the 28th of September, 1759, frightful subterranean noises, which had been heard three months before on the plain of Malpais, again commenced. A tract from three to four square miles in extent rose up in the shape of a dome, and those who beheld the phenomenon asserted that flames rose from an area of more than six square miles. Fragments of burning rocks were projected to an immense height, and the surface of the ground undulated like a rolling sea. Thousands of small cones suddenly appeared, and from among them rose up six great masses to heights varying from 1312 to 1640 feet above the original level of the plain:" the most elevated of these is the volcano of Jorullo.

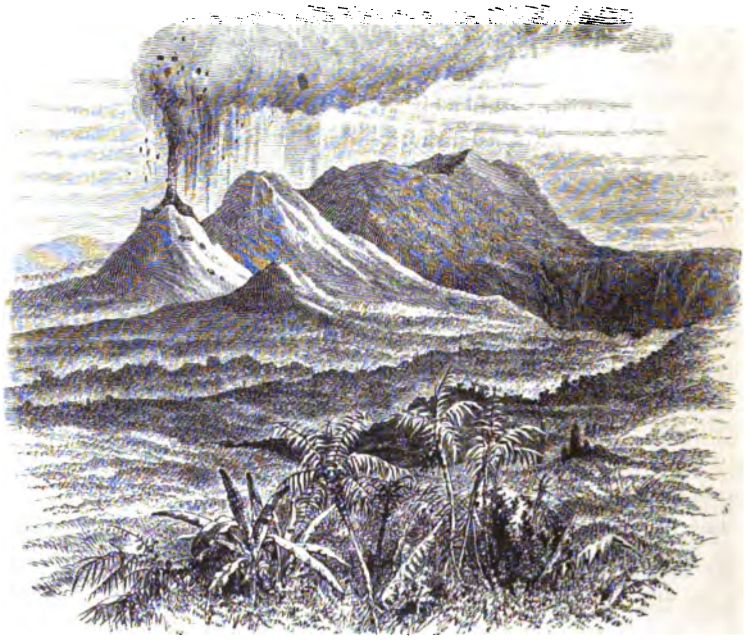
The formation of new islands by volcanic action has already been described. The elevation of coasts from the same cause will be discussed under the subject of earthquakes.

6. **Theory of Volcanoes.**—We have seen, in treating of the structure of the earth, that there is every reason for believing its interior to be a vast reservoir of fluid rock intensely heated; and the repose of this fluid is doubtless liable to be locally disturbed by the expansive force of vapors and gases.

Volcanoes are therefore to be regarded as the upper orifices of long channels, which descend through the crust of the earth to the fiery flood below, where the gathering vapors and gases are at times so compressed that they acquire enormous power; and, forcing up vast streams of melted rock, an eruption, with all its terrific phenomena, is the result. When the accumulated force is expended, the volcano once more reposes, to be again disturbed whenever the imprisoned gases and vapors reassert their might. Volcanoes are the safety-valves of the globe.

7. **Volcanoes classified.**—Volcanoes are divided into four classes,—namely, *active*, *intermittent*, *extinct*, and *semi-extinct*.

Active Volcanoes.—Stromboli, one of the Lipari Isles, and Izalco, in Central America, are instances of the first class. Stromboli is nearly 3000 feet high, and has been active from the most remote times. Homer mentions it, and it was called by the ancients the "Lighthouse of the Mediterranean." Its eruptions are said to take place at regular intervals, ranging from three to five months. Izalco was formed in 1770, when the earth opened at the base of the extinct crater of Santa Anna in San Salvador, Central America, and flames, ashes, and lava issued from the chasm. It has been constantly active ever since, and the cone has risen to the height of nearly 4000 feet. Loud explosions occur with great regularity, at intervals of from ten to twenty minutes, attended with discharges of stones and ashes.


IZALCO, CENTRAL AMERICA.

Give a description of the eruption of Tomboro. How is the energy of volcanoes most strikingly shown? Give an account of the phenomena attendant upon the formation of Jorullo. 6. What is the cause of volcanoes? 7. How are volcanoes classified? Describe Stromboli and Izalco.

It has been observed that the *lower* a volcano is, the more frequent are its eruptions.

Intermittent Volcanoes.—The volcanoes of Etna, Teneriffe, and Cotopaxi, ranging in height from 10,874 feet to 18,887 feet, are examples of the second class, having intervals of repose sometimes centuries in extent. From B.C. 480 to A.D. 1832, fifty-five eruptions of Etna are recorded. From 1800 to 1832, six eruptions occurred; while from 251 to 812, a period of five hundred and sixty-one years, the volcano slumbered. In Iceland, famous for the volcano of Mount Hecla, eruptions have occurred, on an average, every thirteen years, from the earliest period of authentic history.

Extinct Volcanoes.—Extinct volcanoes are those which ages ago were active, but are now at rest. They are very numerous, and are found in all parts of the world; and their craters, as in those of Auvergne and Naples, are often as perfectly formed as those of active volcanoes, and present, both in their structure and composition, undoubted proofs of their igneous origin.

It is possible that an extinct volcano, so called, may in some cases be only one in repose; for, previous to A.D. 63, Vesuvius, which is now active, exhibited the appearance of an extinct volcano. Volcanoes of this kind, in some instances, are filled with deadly gases. Such is the "Poisoned Valley" in Java, about half a mile in circumference, the whole surface of which is covered with the skeletons of men, tigers, pigs, deer, peacocks, and all sorts of birds, the gases with which the valley is filled destroying all animal life that ventures within its limits.

Semi-extinct Volcanoes.—Semi-extinct volcanoes are those which eject no solid matter, but gases and vapors issue from cracks in the ground. The craters of these volcanoes present a desolate appearance, no sign of vegetation being anywhere visible. Where the volcanic action is still powerful, the crater is almost entirely filled with smoke and noxious vapors, and the sides and bottom are covered with deposits of sulphur and other minerals. Such is the Solfatara, near Puzzuoli, in Naples, which the Romans regarded as the entrance of the infernal regions. It is 1400 feet in diameter and 400 feet deep, and is constantly filled with thick smoke and suffocating gases.

8. **Arrangement and Number of Volcanoes.**—Volcanoes are classed, in respect to their arrangement, into two systems,—the *Central* and *Linear*.

Central volcanoes consist of a number of small volcanoes grouped around a central cone which is the seat of the eruptions. Such are the volcanoes of Iceland, the land of frost and fire, and the Peak of Teneriffe, the central cone of the Canaries, which is a group of volcanic islands.

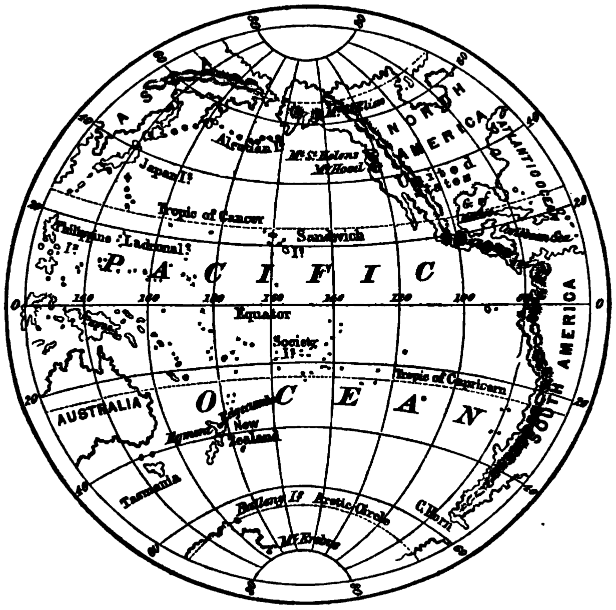
Linear volcanoes are arranged in a line, at varying distances from each other, and are supposed to be vents from the same fissure. Instances of this kind are found in the immense chain of volcanoes extending through the whole length of the Western Continent along the shores of the Pacific, and in that which stretches through the numerous volcanic islands that skirt the eastern shores of Asia, and is prolonged through the Philippine, Molucca, and Sunda groups to the Bay of Bengal.

According to Johnston, the number of volcanoes is 407, including a few of doubtful existence. Of these about 270 are more or less active. They are distributed and arranged as follows:—

CENTRAL VOLCANOES. SYSTEM.	
Etna	1
Vesuvius	1
Lipari Isles	2
Jan Mayen	2
Iceland	8
Azores	2
Canary Isles	7
Cape Verd Isles	1
Ascension	1
Tristan d'Acunha	1
Traverse Island	1
Trinidad	1
Bourbon	3
Hawaii	4
Galapagos Islands	1
Marquesas Islands	1
Society Islands	1
Easter Island	1
Western Asia	3
	42

LINEAR VOLCANOES. SYSTEM.	
Santorini	1
Thian-Shan	2
Red Sea	2
Friendly Islands	2
Australian Islands	13
Sunda Islands	80
Molucca and Philippine Isles, and Formosa	37
Japan	23
Kurile Isles	18
Kamtschatka	21
Ladrone Islands	7
Bonin-Sima Islands	2
Aleutian Isles	35
Northwest America	10
Mexico	7
Central America	38
West Indies	10
Ecuador	17
Peru and Bolivia	12
Chili	22
Terra del Fuego and South Shetland Isles	4
South Victoria Land	2
	365

9. **Geographical Distribution.**—It will be seen from this table that volcanoes are distributed all over the globe, yet not uniformly. Mount Esk, in the island of Jan Mayen, 70° 49′ north latitude, is the most northern volcano, and Mount Erebus, situated in South Victoria Land, in 77° 32′ south latitude, is the most southern. The torrid zone abounds in volcanoes; but of all the volcanic regions of the globe, Java is the most remarkable; for, though only about the size of the State of New York, it contains, according to the latest researches, forty-six volcanoes, of which twenty are active, and whose eruptions are of the most fearful and destructive character.



THE PACIFIC GIRDLED BY VOLCANOES.

By far the greater number of volcanoes, and of those which are

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Give instances of intermittent volcanoes. What is said respecting extinct volcanoes? What is said respecting semi-extinct volcanoes? 8. How are volcanoes classified in respect to their arrangement? What are central volcanoes? Give instances. What are linear volcanoes? Give instances. What is the number of volcanoes? How many are more or less active? 9. What is said respecting the distribution of volcanoes? What country abounds in volcanoes?

active, girdle the vast Pacific Ocean as with a belt of fire. This mighty chain, beginning with the Kamtschatka series, runs south through the Kurile, Japan, Molucca, Philippine, Sunda, and Australian Isles, to the volcanoes of Mount Erebus and Mount Terror, in South Victoria Land. Thence, returning on the eastern side of the Pacific, the series is prolonged through South America, Central America, and Mexico, and the northwest coast, and the circuit is completed through the Aleutian Isles.

This immense zone contains more than six-sevenths of all the volcanoes of the world, and five-sixths of all that are active. The fact that so many volcanoes are situated near the sea-coast and on islands, and that eruptions sometimes occur in the depths of the ocean, has led to the belief that these phenomena are caused by the waters of the sea penetrating to the central fires of the globe. But the existence of volcanoes far distant from the ocean or any considerable body of water, tends to disprove this theory. Popocatepetl in Mexico, and Peshan and Hochow in Central Asia, are instances of inland volcanoes.

Popocatepetl is 132 miles from the sea. Peshan is 1530 miles from the Arctic Ocean, and the nearest large body of water is the salt lake of Issi Kul, 174 miles distant. Hochow lies 670 miles to the east of Peshan. In the view of Humboldt, volcanoes are usually found near the sea, because the coast-lands form the edges of the deep-ocean basin, where the crust of the earth is thinner by many thousand feet than on the continents, and opposes less resistance to the subterranean forces.

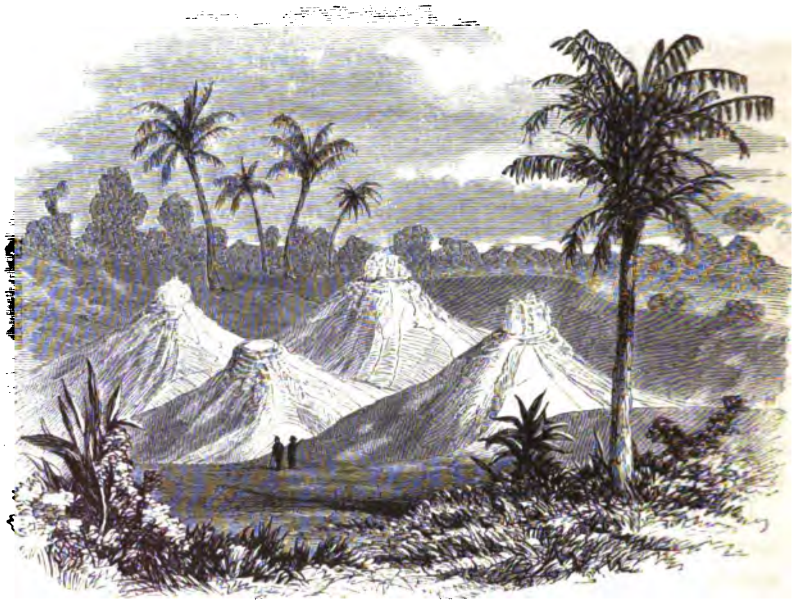
Wrangell's Volcano, on the Copper River, Mount St. Helens, and Mount Hood are all in volcanic activity. On the 19th and 20th of August, 1859, dense volumes of smoke and vapor were seen, by observers at Portland in Oregon, issuing from the crater of Mount Hood, and throughout the night these dark columns were illumined by shafts of flame. The volcanic energy on the northwest coast of America is, however, but feeble.

10. **Analogous Phenomena.**—The effects of the central fires of the globe are revealed not only in true volcanoes, but in eruptions of mud, discharges of inflammable and other gases, and ejections of hot water.

Mud-Volcanoes.—A region near the mouth of the Indus, 800 square miles in extent, is covered with mud-volcanoes. One of the cones is about 400 feet high, and is formed of light-colored earth. It has a crater at the top ninety feet in diameter, filled with liquid mud. The mud-volcanoes of Turbaco, as described by Humboldt, consist of about twenty cones, varying in height from nineteen to twenty-five feet, their craters being filled with water and soft clay. More than twice a minute, bubbles of gas burst up through the liquid mass with considerable noise, and with sufficient force to cause the water to flow over the rim.

The mud-volcanoes of Aguachapa, in Central America, are known to have been in action for the last three hundred years. A dense white steam rises from a semi-fluid mass of mud and water, which boils furiously, and the ground all around is too hot to tread upon. In Central Asia, Sicily, Java, and Trinidad, mud-volcanoes are likewise found.

Field of Fire.—The district of Bakou, situated west of the Caspian Sea, not only abounds with mud-volcanoes, but also contains a large depressed region, termed the *Field of Fire*. The soil is here impregnated with naphtha, and the surface is filled with cracks, some of which emit flames, and others smoke and inflammable gases. This locality was the famous shrine of the Ghebers, or Fire-Worshippers, of Persia.



MUD-VOLCANOES OF TURBACO, SOUTH AMERICA.

Fire-Springs.—Fire-springs are fountains of water mingled with streams of inflammable gas, which rise from the earth either through artificial borings or natural vents. In China, borings have been made to depths ranging from 1500 to 3000 feet, for the purpose of procuring salt water. From some of these orifices inflammable gas issues in such volumes that, when fire is applied, a blue flame rises to the height of from twenty to thirty feet, with great noise and force, and is used for evaporating the salt water.

A few years ago, borings were made for brine near the Great Kanawha River, in West Virginia. When the salt water was reached, a large and constant stream of inflammable gas issued forth with great violence. It was employed as fuel, and furnished a constant sheet of flame, several feet wide and one hundred and fifty feet long, which was used for evaporating the brine. More than a year elapsed before the supply of gas was exhausted.

Natural springs of this character are sometimes found. The subject of hot springs will be discussed in a subsequent chapter.

CHAPTER VII.

EARTHQUAKES.

1. EARTHQUAKES and volcanoes are most closely connected, since they arise from the same cause. One may occur, however, without the other, or both may convulse the earth at the same time. Of these two dreadful visitants, the earthquake is the most fearful. It comes in a moment, with overwhelming and wide-spread destruction, which no foresight can avoid and no power withstand. But the volcano gives warning of the impending ruin, and the lava-flood is

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What is remarkable respecting the Pacific Ocean? Describe this zone. What has been inferred from the situation of volcanoes near and in the sea? What is Humboldt's view? What volcanoes are active in Northwest America? Mention the eruption of Mt. Hood. 10. What other phenomena are to be attributed to the action of the central fires? Give an account of mud-volcanoes. Describe the Field of Fire. What are fire-springs? Give the instances cited.

What is the subject of Chapter VII.? 1. Is there any connection between volcanoes and earthquakes? Which of the two is the most to be dreaded, and why?

confined in its action, and its sluggish movements afford time to escape from its perils.

2. **Concussions of Earthquakes.**—The concussions of earthquakes are commotions of the solid crust of the earth, more or less extended, which vary in intensity from the slightest vibrations to the most violent and appalling convulsions.

These movements are of three kinds,—*vertical, horizontal,* and *rotatory,*—which follow each other rapidly, but are sometimes combined. The vertical movement is an upward, mine-like explosion, of which the earthquake that destroyed the town of Riobamba in Ecuador, on the 4th of February, 1797, is a remarkable instance. During its occurrence the bodies of many persons were thrown from the town across a river to the top of a hill several hundred feet high.

Dr. Tschudi relates that on the 4th of July, 1839, while he was leaning against the prostrate trunk of an immense tree in the primeval forests of South America, it was suddenly raised a foot and a half by the upward shock of an earthquake.

The *horizontal* movement is of a twofold character,—*tremulous* and *undulatory.* The first has been compared to the tremors that run through a steam-vessel under the powerful strokes of the engine. In South America these shocks are called *temblores,* and are quite common. In Lima, according to Dr. Tschudi, forty-five shocks take place on an average every year, most of them occurring between October and June. They are comparatively harmless: slightly-built walls are occasionally thrown down, but life is not endangered by them.

The *undulatory* movements, which are fearful in their effects, are wavelike motions that cause the surface of the earth to rise and fall alternately, like the billows of the sea. They are termed by the South Americans *terremotos.*

The *rotatory* movement is rare, occurring only in the most violent earthquakes; but it is very destructive. It consists in twisting objects around without overthrowing them: roofs are made to fall while the walls are left standing; parallel rows of trees are deflected, and the positions of fields changed. In the earthquake that happened at Calabria in Sicily, in 1818, statues were turned around, and a large rock which, before the earthquake, lay in its length from north to south, after this event ranged east and west.

During the earthquake at Valparaiso in Chili, in the year 1822, two solid brick buttresses, six feet square, which survived the ruins of the Church of La Merced, were twisted in a northeasterly direction, each presenting an angle to the wall. In the great earthquake of Calabria in 1783, a plantation of mulberry-trees was carried into the midst of a field of grain, and a plot of ground sown with lupines was borne into a vineyard. Rotatory motions are supposed to be produced either by a union of vertical and horizontal movements, or by several undulations crossing each other simultaneously at different angles.

3. **Progression.**—In regard to their progression, earthquakes are either *linear* or *central.* In the former, the undulations are propagated in a straight line; in the latter, they are either circular or elliptical, and expand outward from the centre of disturbance, decreasing in intensity with their distance from the same. The areas of disturbance are either circular or oval in form. The linear earthquakes occur most frequently in countries traversed by mountain-ranges, the undulations advancing with a velocity of from twenty-three to thirty-five miles a minute.

The earthquake which happened at Guadeloupe in the West Indies on the 8th of February, 1843, is one of the best examples of this kind. Its undulations were from sixty to seventy miles wide, and were propagated northerly to New York and southerly to the Amazon River, through a distance of 3000 miles, at the rate of from twenty-five to twenty-seven miles a minute.

In central earthquakes the areas of commotion vary greatly in extent. In the Calabrian earthquake of 1783, of which the town of Oppido was the centre, the most intense shocks were confined to an area of five hundred square miles: within this region two hundred towns and villages were destroyed and 100,000 persons perished. In the great central earthquake of Lisbon, which began on the 1st of November, 1755, the vibrations extended over a tract equal in extent to one-twelfth of the whole surface of the globe.

AN EARTHQUAKE IN SOUTH AMERICA.

4. **Duration.**—No other natural calamity crowds such an amount of suffering and ruin into so small an extent of time as the earthquake. In those of Caraccas and Lisbon, most awful in their effects, the catastrophe occurred within the space of six minutes in the first instance, and within that of only one minute in the second.

5. **Sounds.**—The subterranean noises that attend earthquakes are various. Tschudi remarks, "They resemble for the most part the rattling of a heavily-loaded wagon driven rapidly over an arch. They usually accompany the shock, but seldom precede it; and only in a few cases do they follow it, muttering like distant thunder. On one occasion the noise appeared to me like a groan from the earth, accompanied by sounds like the crackling of wood when an old house is consumed." This description agrees with those given by other observers.

These sounds are sometimes heard at places far distant from the seat of the earthquake with the same distinctness and at precisely the same time. When the volcano of St. Vincent, in 1812, burst forth with terrific earthquakes, a loud noise, unattended by shocks, was heard simultaneously at Caraccas, on the banks of the Apure River,—a distance of 700 miles. A like phenomenon took place at the eruption of Cotopaxi in 1744; for at the moment of eruption a subterranean noise, like thunder, was heard at Honda, in the valley of the river Magdalena, 500 miles distant. From such facts it is

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2. What are concussions? Mention the different kinds. Give instances of vertical motion. What is the nature of the horizontal motion? Describe the first kind. Describe the second kind. When does the rotatory motion occur? What is its character? Cite the instances illustrating its effects. How is the motion caused? 3. How are earthquakes classed in respect to their progression? Describe the nature of the undulations in linear earthquakes. Of those in central earthquakes. Where do linear earthquakes most frequently occur? What is their speed? Cite the instance given. What is said of the extent of central earthquakes? Give the examples. 4. What is said respecting the duration of earthquakes? 5. Describe the subterranean noises which attend these phenomena. Are these sounds ever heard simultaneously at places wide apart? Give examples.

inferred that the sounds are not communicated from place to place through the air or the solid crust of the earth, but that their source is deep in the interior, at nearly equal distances from the places where the sounds are heard. Sometimes earthquakes occur without any noise, and at others the noise happens without the earthquake; but these instances are rare. It is stated by Humboldt that no noise accompanied the dreadful earthquake of Riobamba, in 1797, when the town was laid in ruins and from 30,000 to 40,000 people were killed. The same phenomenon was observed in the earthquake that overthrew Lima and Callao, in 1746.

On the other hand, a subterranean noise, like the rolling of thunder, interrupted with short, loud claps, was heard, for the space of a month, at Guanaxuato in Mexico, in 1784, without the slightest movement of the ground being detected. In the mines near this town the noises were as loud at the depth of 1600 feet as at the surface.

6. **Effects of Earthquakes.**—These are of two kinds,—*transient* and *permanent*. The first includes all those appalling phenomena that attend a severe earthquake, such as the desolation and ruin of provinces and cities, the destruction of human life, and the commotions of the land and sea. The second relates to the partial upheaval and sinking of the surface of the earth.

The greater number of earthquakes pass away without leaving any marks of their occurrence; but others are awfully destructive. A volume might be filled with descriptions of the latter; but an account, given by eye-witnesses, of two,—that of Lisbon in Portugal, and of Caraccas in Venezuela,—both remarkable for their severity, will suffice to unfold their terrible nature.

At Lisbon, about half-past nine o'clock in the morning, on the 4th of November, 1755, a rumbling subterranean noise, like the rolling of carts, was heard, which gradually increased, and, after a few seconds, resembled the firing of heavy cannon. At this moment the first shock was felt, which levelled the Palace of the Inquisition and several churches. Three other shocks followed within the space of *five minutes*, prostrating nearly all the remaining large buildings,—palaces, churches, convents, public offices, and houses.

Half an hour later the sea, rising forty feet above high-water mark at the mouth of the Tagus, rushed upon the devoted city with incredible speed, overflowing the lower streets, and hurling bottom upwards a stone quay with three thousand people upon it who had fled thither for safety from the falling city. The wave retreated as quickly as it came, returning three times, but at each time with less violence. By the earthquake and inundation 60,000 persons perished; and to the horrors caused by these were added the ravages of fire. "As soon as it was dark," says Mr. Davy, "the whole city appeared in a blaze, which was so bright that I could easily see to read by its light. It was on fire in a hundred different places, and continued to burn for six days without intermission."

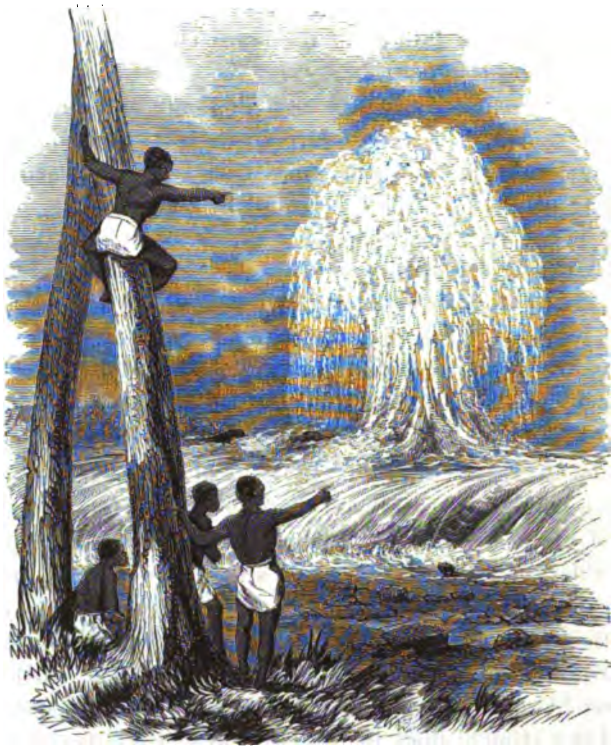
At Oporto, north of Lisbon, the earthquake-shocks were very severe. At Cadiz, to the south, the sea rose sixty feet above its level, and rolled in a huge wave over the land, demolishing the walls and fortifications of the city on the ocean side. The highest mountains of Portugal were convulsed and rent asunder, and vast masses of rock hurled into the valleys; a town near Morocco is said to have been destroyed with 8000 inhabitants; and the earth was shaken throughout the immense area already mentioned.

The earthquake of Caraccas occurred on the 26th of March, 1812, during a calm and cloudless day. It was Holy Thursday, and most of the population were collected in the churches. At seven minutes past four o'clock P.M. the first shock was felt, which caused the bells of the churches to ring and the earth to undulate like a stormy sea. It lasted about six seconds, and was followed by a rolling, subterranean noise louder than the loudest thunder.

This was succeeded by a perpendicular shock, which lasted three or four seconds, closely followed by undulations which crossed each other. In about the space of a minute the city was levelled to the ground, and 10,000 people buried beneath the ruins of the churches and houses.

The effect of the earthquake upon the ocean was strikingly displayed at Simoda, in Japan, on the 23d of December, 1854, when, after an earthquake, five tremendous waves, alternately rolling shoreward and receding, overwhelmed the town, carried the largest junks two miles inland, and wrecked the Russian frigate Diana, which was then lying in the harbor. These waves were propagated across the Pacific Ocean, and were perceived on the coast of California.

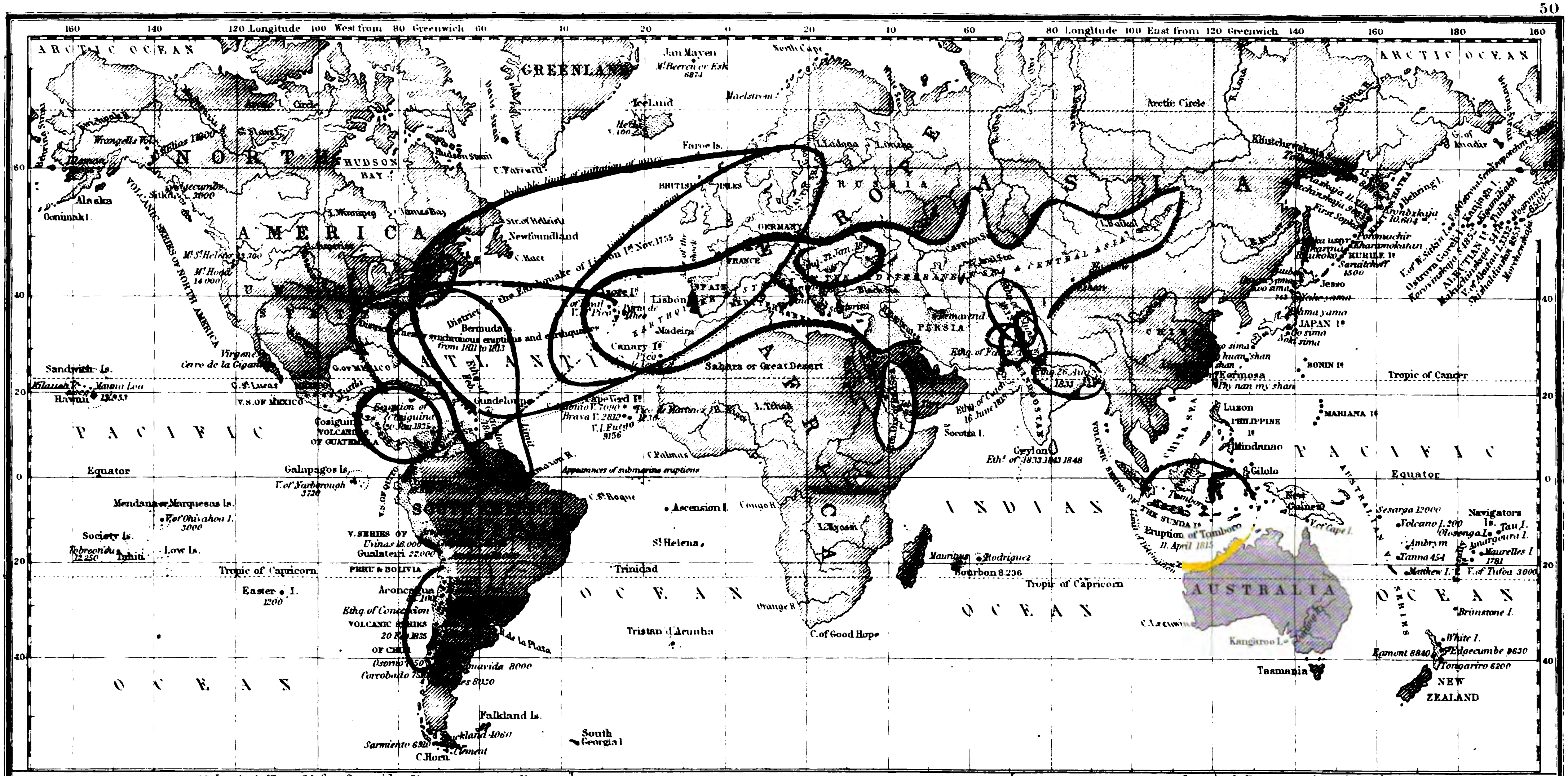
In Honduras, where earthquakes are frequent, a traveller thus describes a similar phenomenon, which occurred in the Criba Lagoon, at San José, Central America, on August 3d, 1856:—"Away went the waters, far towards the sea, leaving the bottom of the lagoon dry, while a small island rose from the centre like a conical hill in some vast plain. The lagoon is here five miles broad, and a valley was formed in the centre by the retreating waters. But we had no thought of the danger that awaited us when they should return; and they came upon us in a moment. From every direction the waters rushed to a common centre, where, meeting, they rose in the air in an immense column; then, falling, they came towards the

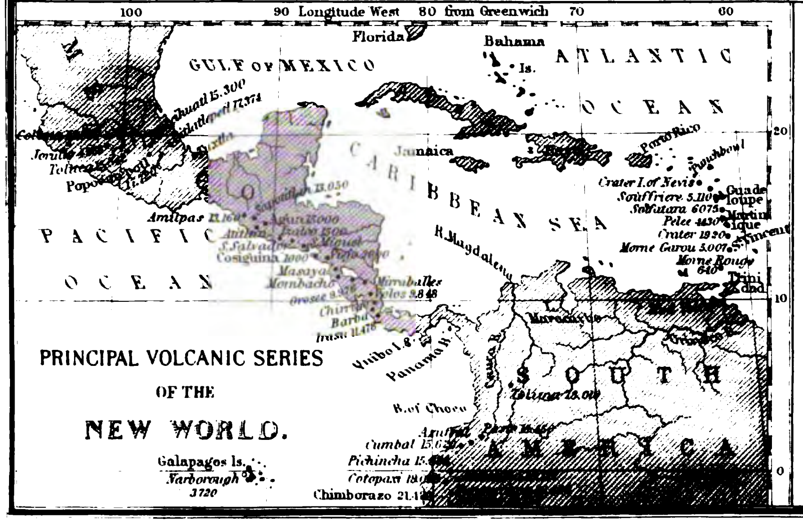


MEETING OF THE WATERS, CRIBA LAGOON, HONDURAS.

What is inferred from such facts? Do these noises and earthquakes always occur together? Cite the examples of Riobamba and Guanaxuato. 6. How are the effects of earthquakes classified? What phenomena does the first kind comprise?

Are all earthquakes destructive? Give an account of the earthquakes of Lisbon and Caraccas. Describe the effect of the earthquake upon the ocean as displayed at Simoda. Describe a similar effect at Honduras.





PRINCIPAL VOLCANIC SERIES
OF THE
NEW WORLD.

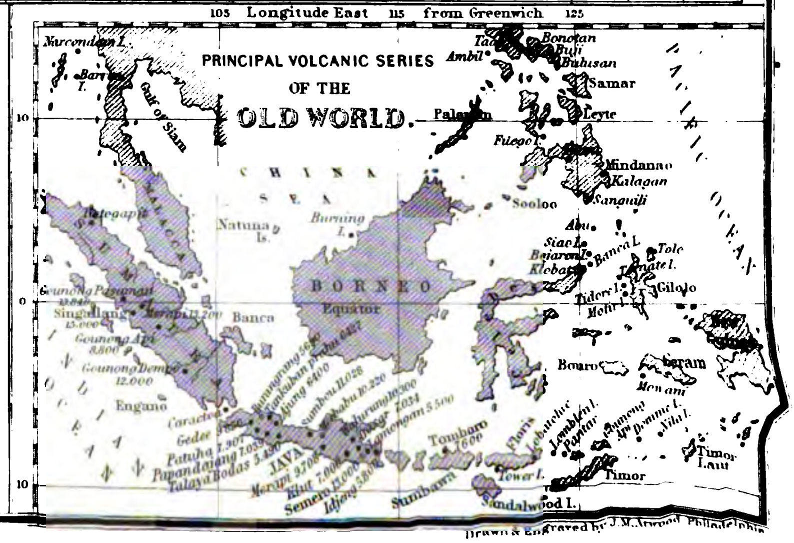
Nº 2.

MAP OF THE WORLD
SHOWING THE DISTRIBUTION OF
VOLCANOES
AND THE REGIONS SUBJECT TO
EARTHQUAKES.

Explanations.

Active Volcanoes are marked thus ●
Extinct Volcanoes ●
Central Groups by a blue circle
Earthquake Districts

The shading of the regions subject to Earthquakes is darker in proportion to the violence and frequency of the shocks, and the red lines denote the area throughout which they were felt. The figures placed beside the names of the Volcanoes express their height in feet.



PRINCIPAL VOLCANIC SERIES
OF THE
OLD WORLD.

Drawn & Engraved by J. M. Atwood, Philadelphia land with the force of an avalanche, threatening us with instant destruction."

Among other transient effects may be included discharges of water, vapor, smoke, noxious gases, mud, and stones. In the Jamaica earthquake of 1692, clouds of vapor ascended from the riven ground, diffusing an intolerable stench; and in that which destroyed the town of Aquila, in Italy, vast volumes of gas and vapor issued from the ground, and columns of water rose to the tops of the trees, throwing out great quantities of mud and stones.

7. **Permanent Effects.**—By the force of earthquakes the elevation of large regions is sometimes permanently changed. On the 2d of April, 1762, the town of Chittagong, in Bengal, was shaken by an earthquake; and, during its continuance, sixty square miles of the Chittagong coast suddenly and permanently subsided. A large river was swallowed up, one mountain entirely disappeared, and the top of another only remained visible. Chasms were opened from thirty to sixty feet wide, and towns submerged to the depth of twenty feet. While this coast was sinking, a corresponding rise took place at the island of Ramree and at Cheduba.

During a terrific earthquake that occurred in India, in the district of Cutch, on the 15th of June, 1819, the land on the coast sunk, and the sea rushed inward over an area of 600 square miles, forming an extensive lake; while to the north the ground rose to the height of ten feet, throughout a tract about fifty miles long and sixteen miles wide. This elevation was called by the natives Ullah Bund, or, "God's Dike."

The earthquake which occurred at Chili in 1822 raised the land from two to three feet along the coast for a distance of 100 miles; and in another great earthquake which convulsed these shores in 1835, the island of Santa Maria was elevated from eight to ten feet. Nearly all severe earthquakes produce cracks and chasms of considerable extent. After the great earthquake of Calabria, in 1783, the fissures were so numerous in the vicinity of Polistina that the road became impassable.

8. **Influence on Animals.**—It is asserted by observers that at the approach of an earthquake the inferior animals exhibit great restlessness and trepidation. Rabbits, moles, rats, and lizards leave their holes and run wildly about; dogs howl, and horses, trembling and filled with fear, burst from their stalls: even the sluggish crocodile leaves the river and hastens with loud cries into the woods.

9. **Extent of Earthquakes.**—Earthquakes occur with more or less severity in regions far distant from the seats of intense volcanic action.

At New Madrid, in Missouri, in 1811–12, a tract seventy-five miles long and thirty broad was depressed, during an earthquake, to the depth of several feet. The earth rose and sunk, wide chasms were made, and huge columns of mingled water, sand, and other materials spouted to a great height. Lakes twenty miles long were formed in an hour; and so high did the ground rise that the direction of the current of the Mississippi was temporarily reversed. Vestiges of these effects were visible in 1846.

Earthquake-shocks were early noticed in New England. Newburyport in Massachusetts is said to have experienced several hundred. Between the 1st of January, 1852, and the 10th of June, 1855, from forty to fifty shocks were felt in California, and eighty-four in ten other States. Virginia and Georgia had the greatest number, each having eight shocks within this period.

What other transient effects are mentioned? 7. Give an account of the permanent effects of earthquakes. 8. What are the effects of earthquakes on animals? 9. Do earthquakes occur in regions far distant from the seats of intense volcanic action? Give instances.

REVIEW AND MAP QUESTIONS ON VOLCANOES AND EARTHQUAKES.

VOLCANOES.

Mention the two classes of eruptions.
What kind of eruption occurred at St. Vincent in 1812?
Where is this island situated?
In what island are Mauna Loa and Kilauea?
To what kind of eruptions are they subject?
Where is Tomboro?
Name the active volcanoes on the northwest coast of North America.
Name some of those of Central America and Mexico.
Mention the principal active volcanoes of South America.
Where are the principal linear volcanoes of the Western Continent?
Within what parallels of latitude do the principal volcanic chains of the Western Continent lie?
In what part of the continent is the principal chain found?
What ocean does it skirt?
Are there volcanoes in the West India Islands?
Name them.
Where are the principal linear volcanoes of the Eastern Continent?
What are its principal chains?
In what country are volcanoes numerous for its size?
Mention some of the active volcanoes of the Eastern Continent.
Between what parallels of latitude are the chief series found?
What chain extends between America and Asia?
Is there any thing remarkable in the Pacific Ocean as respects volcanoes?
What volcanoes exist in Central Asia?
Are central volcanoes most numerous in continents, or in the ocean?
What central groups are found in the Pacific Ocean? The Atlantic? The Indian Ocean?
What extinct volcano is in the Azores?

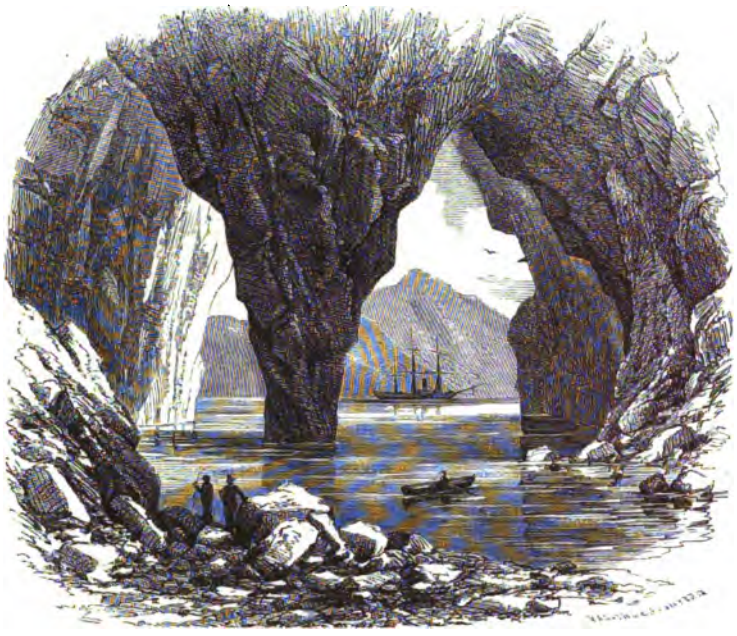
EARTHQUAKES.

Describe the earthquake regions of the Western Continent.
Near what ocean are they chiefly situated?
Within what parallels of latitude do they lie?
In which of these regions are earthquakes most frequent and violent?
In which least?
Give the limits of the earthquake of Concepcion in Chili in 1835.
That of Guadeloupe in 1843.
Give the limit of the region of synchronous eruptions and earthquakes from 1811 to 1813.
Mention the earthquake regions of the Eastern Continent.
In which of these are earthquakes most frequent and severe?
In which least?
Give the limits of concussion in the earthquake of Lisbon on November 1, 1855.
Give the probable limits of undulations.
Bound the earthquake districts of the Mediterranean and Central Asia.
Describe the Red Sea district.
Give an account of the limits of the earthquakes of India and Central Asia, as shown on the map.
Give the limits of the earthquake district during the eruption of Tomboro.

CHAPTER VIII.

CAVERNS AND NATURAL ARCHES.

1. **When** we reflect upon the manner in which the crust of the earth was formed, its upheaval by volcanic forces, and the constant erosion of the rocks by the action of water, we are prepared to believe in the existence of vast open spaces beneath the surface of the ground, of yawning chasms, and of rocks and mountains tunnelled and arched by the hand of nature.



NATURAL TUNNEL, BONIN ISLANDS, JAPAN.

Caverns.

2. **Caverns** chiefly occur in limestone, but are likewise found in sandstone and in volcanic rocks. They consist principally of three kinds: the first are narrow fissures, piercing deeply into the earth, and open at one end; the second, tunnelled caves open at both extremities; and the third, and most frequent, consist of a series of cavities or chambers connected with each other by passages of varying extent.

Eldon Hole, in the Peak of Derbyshire, is an example of the first class. It is a chasm, in limestone, sixty feet long and twenty wide. In 1781 it was explored to the depth of two hundred feet; but at the bottom a fissure was discovered which has not yet been sounded.

The most extraordinary abyss is that of Frederickshall, in Norway. Upon throwing a stone into this fissure the sound of its fall is heard after an interval of about a minute and a half or two minutes, which gives a depth of 59,049 feet for the longest time, and 39,866 for the shortest.

The mountain of Torghätten, in Norway, affords an example of the second class. According to Malte Brun, it is pierced by an opening 150 feet high and 3000 feet long; and twice in the year the sun darts his rays through this shaft from one extremity to the other. A great number of such tunnels are found on the coast of the island of Heligoland and upon the shores of New Zealand.

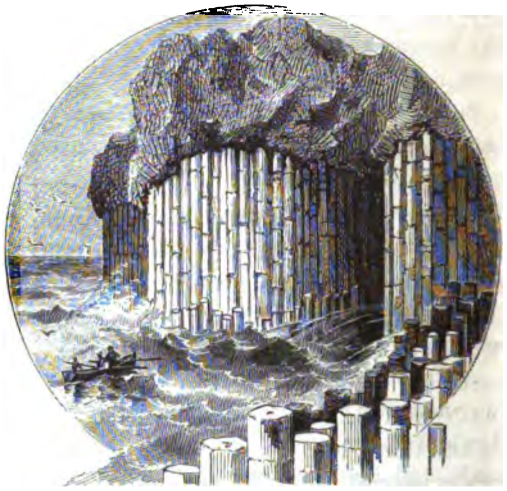
In the Bonin Islands, in the Sea of Japan, similar formations exist. Within the harbor of Port Loyd there is a very curious natural tunnel, which passes through basaltic rock from the Southern Head to the beach on the other side. The entrance is about fifteen feet wide and thirty high; but the roof within soon rises to the altitude of forty or fifty feet, and has almost precisely the appearance of an artificial arch. The water is sufficiently deep for a boat to row through the tunnel. There are likewise here several other arches of this nature: one of these, 150 feet long, passes through a headland bounding the harbor, and is constantly traversed by the canoes of the natives.

Caverns of the last class are the most interesting of all, on account of their great extent, the grandeur, beauty, and variety of their subterranean scenery, and the grotesque and fanciful forms assumed by their mineral concretions.

3. **Volcanic Caves.**—Fingal's Cave, in the isle of Staffa, is the finest known example of a cavern of the third kind, formed by volcanic rocks. The isle of Staffa consists of pillars of basalt, its name, signifying a *staff* or *column*, being derived from its peculiar structure. The basaltic columns that constitute the island have been broken away by the power of the waves, and various caves have thus been made, the grandest of which is the cave of Fingal.

This magnificent structure, according to Sir Joseph Banks, is 371½ feet long, the breadth at the entrance is 53½ feet, and the height 117½ feet, the depth of the water varying from 9 to 18 feet. The floor is composed of a lava-like substance, with ranges of regular basaltic columns resting upon it and supporting the massive rock-work that forms the ceiling. From the murmur of the waves within the cave, it is called, in the Gaelic tongue, "Llaim-binn," or, the Cave of Music.

In the torrent of lava that flowed from the Bald Yökul, in Iceland, a vast cavern occurs, forty feet high, fifty broad, and nearly a mile long. Masses of beautiful black lava, shaped like icicles, hang from the roof; the sides are variegated with vitrified horizontal bands, and the floor is covered with solid ice, clear as crystal.



FINGAL'S CAVE, STAFFA.

4. **Limestone Caves.**—Caves which are formed of limestone are distinguished from others by mineral incrustations, termed *stalactites*[1] and *stalagmites*,[1] which are produced by water, impregnated with lime, that trickles through the roof. Part of this water evaporates upon the roof, leaving the lime, which, in process of time, forms

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[1] From the Greek word *stalazo*, to drip.

What is the subject of Chapter VIII.? 1. Is the existence of caves and natural arches probable, from what we know respecting the forces to which the earth has been and still is subject? 2. How many kinds of caverns are there? Define them. Describe Eldon Hole and the abyss in Norway. Describe the tunnel at Torghätten. Where are other tunnels found? Describe the arches at the Bonin Islands. What is said respecting caverns of the third class? 3. Describe Fingal's Cave. What cave is found in the lava of Iceland? 4. For what formations are limestone caves remarkable?

a pendent mass like an icicle: this is the *stalactite.* That portion of the water which falls upon the floor also evaporates, and the lime that is deposited rises from the floor in pyramidal shapes: these are *stalagmites.* Not unfrequently the ascending stalagmite and the descending stalactite meet and blend together, forming columns, arches, and grottos, and sheets and curtains of translucent stone.

The cave of Adelsberg, about six miles from Trieste, in Austria, is a limestone cave remarkable for its length and height. The entrance is through a fissure apparently produced by an earthquake. The cave consists of various halls and grottos, adorned by an immense number of translucent pillars as white as snow. The bottom is covered with similar concretions; while from the roof hang numerous stalactites, which, beneath the blaze of torches, dazzle with their radiance. The sides of many of the grottos are draped with the same brilliant incrustations, so thin and transparent that they descend like delicate crystal curtains to the floor.

Abysses five and six hundred feet deep are found within this cavern; and amid its recesses a river winds its course, spanned by two bridges, a mile apart, formed of stalagmites. One of the bridges is from 500 to 600 feet above the stream. "At every step," says a recent traveller, "the scene shifts like a panorama. Now the cave is so low that the explorer is obliged to stoop, and now so high that the roof is lost in the gloom. At one time we saw the guides lighting up some distant gallery far above our heads, which had all the appearance of a veranda adorned with Gothic tracery. At another time we came into what seemed the long-drawn aisles of a Gothic cathedral." One of the numerous rooms is called the Ball-room, where the inhabitants of Adelsberg and the vicinity assemble every Whitmonday, when the grotto is brilliantly illuminated for the dance. Within the darkness of this cavern lives the Proteus,—a singular animal, white and transparent, with a shape between those of the lizard and the eel.

Wier's Cave, situated in Rockingham county, Virginia, though not very extensive, is one of exceeding beauty. Its length in a direct line is 1600 feet; but, with all its windings, it measures about 3000 feet. Here magnificent halls and galleries succeed each other, adorned with the richest profusion of dazzling incrustations wrought into the most singular forms. "At every step," says a late visitor, "strange and beautiful objects flash into being,—pillared walls hung with sweeping folds of tapestry, niches filled with shadowy sculpture, vaulted and groined ceilings, and fluted columns whose tops were lost in the darkness." In one grotto, termed the Music-room, sheets of incrusted matter fall from the ceiling to the floor. These natural curtains, between which the explorer may walk, are thin and translucent, and glow with a brilliant light when torches are placed behind them. In the "Bridal Chamber" a most delicate incrustation hangs like a veil over what is called the "Toilet-table."

The Mammoth Cave of Kentucky is the most remarkable curiosity of this kind, and is the largest cave yet discovered. It contains two hundred and twenty-six avenues and galleries, forty-seven splendid chambers and halls, twenty-one deep abysses, eight cataracts, several lakes, and three rivers, one of which is three miles long and deep enough to float a ship. Audubon Avenue, near the entrance, is more than a mile long, from forty to fifty feet wide, and as many high. Gothic Avenue, which is three miles long, is adorned with pillars and arches, pendants and groins, like the interior of some stately cathedral. An immense vault, called the Temple, comprises an area of two acres, crowned by a dome of solid rock one hundred and twenty feet high. The Mammoth Dome, four hundred feet in height, overarches a hall of great beauty and magnificence. The Dead Sea is a lake of considerable extent, within which are found the Pisces Bartimei, or eyeless fish.

DEAD SEA, MAMMOTH CAVE.

5. Zoolitic or Bone Caverns.—Many caverns possess a high interest from the fact that they are the depositories of the remains of extinct races of animals, and thus afford much information respecting the geological changes of the globe. Such caves have received the name of *zoolitic* or bone caverns.

In 1821 a cave of this kind, 250 feet long, was discovered at Kirkdale, in Yorkshire, the mouth of which had been choked up with rubbish and overgrown with grass and bushes. Here, under a sheet of calcareous deposit, was found a layer of loam, from two to three feet thick, filled with an innumerable quantity of bones belonging to the hyena, bear, tiger, lion, elephant, rhinoceros, hippopotamus, deer, water-rat, and mouse,—all of them the remains of extinct species.

Of this character, in England, are Kent Cavern in North Devon, Dream Cavern near Wirksworth, and the Cave of Crawley Rocks near Swansea. In Germany, bone caverns are more numerous and interesting than those of England. The Cave of Gailenreuth, in the chain of the Jura, consists of two principal chambers; and in the earthy floor of the lowest the bones of an extinct species of bear are abundantly found. Near this is the cave of Kuloch, in which it is computed the remains of 2500 individuals of the cavern bear lie entombed.

6. Gas Caves.—Caverns occur in volcanic regions which produce irrespirable gases. Such is the famous Grotto del Cane, at Naples. It is of small size, being ten feet long, four broad, and nine high. The floor is covered with carbonic acid gas (which is heavier than the air) to the depth of six inches. Dogs sent into the cave are suffocated in a short time; and from this mode of experiment the cave derives its name. The Dunsthohle Cave, near Pyrmont, exhibits the same phenomena.

How are these produced? What is said respecting these concretions? Describe the cave of Adelsberg. What animal is found here? Describe Wier's Cave.

Describe the Mammoth Cave. 5. What are zoolitic caverns? Describe those mentioned. 6. What are gas caves? Describe the Grotto del Cane.

Natural Arches.

7. Throughout every part of the world natural arches and bridges are found. They are supposed to be caused in several ways, as by rocks falling over ravines and becoming wedged together, or by the erosive action of streams, or by some convulsion of nature which has rent away the lower portion of a rocky wall and left the upper part unbroken.

NATURAL BRIDGES OF ICONONZA, UNITED STATES OF COLOMBIA.

The Natural Bridge of Virginia is one of the most celebrated natural arches in the world. It is situated in Rockbridge county, and crosses Cedar Creek, which here flows between broken cliffs two hundred and fifty feet high. A magnificent arch, of ninety feet span and eighty feet wide, unites the opposite banks at the height of two hundred and twenty feet above the water. A public road crosses the arch, which is fifty-five feet thick, and is covered with a clay soil sufficiently deep to support a thick growth of arbor vitæ. These trees, with the masses of rock that form parapets on either side, so effectually conceal the ravine from the traveller that he might cross the arch unconscious of the wonder beneath him.

Near Bogota, in Colombia, are the natural bridges of Icononza, consisting of masses of rock lying across a chasm of great depth. Through this rushes the Summa Paz, forming a beautiful cascade where it enters the ravine, and another where it leaves it. A natural arch, forty-seven feet long and thirty wide, spans the abyss, at the height of 318 feet above the torrent. Sixty-four feet below this bridge is a second, composed of three immense rocks, which have so fallen that they are wedged together and arch the ravine. In the middle of the arch is an opening, through which are seen, far below, the dark, tumultuous waters of the river, overshadowed by thousands of nocturnal birds that haunt its gloomy channel.

The Inca's Bridge, which is situated in the Argentine Confederation, is more remarkable for the mode of its formation than for its size. According to Mr. Darwin, it is composed of fragments of rock cemented together by deposits of lime from the hot springs in its vicinity. The stream which flows beneath it appears to have scooped out a channel on one side, leaving an overhanging ledge, which was met by stone and earth falling from the opposite cliff; and the two portions, thus uniting, formed the arch.

In Palestine a splendid natural arch spans the Nahr el Leben, or "River of Milk." It is 157 feet long, from 80 to 100 feet wide, and its altitude nearly 200 feet. Across it passes the highest public road in the land, which winds along the loftiest cliffs of Lebanon.

CHAPTER IX.

MINERAL PRODUCTIONS.

1. The chief mineral products of the globe may be arranged for the most part under the following classes:—*Building Materials, Precious Stones, Metals, Coal, and Salt.*

Building Materials.

The principal minerals employed as building materials are *Granite, Sandstone, Calcareous Rock,* and *Slate.*

2. **Granite** possesses great strength and hardness, and is admirably suited for vast and enduring structures. Syenite and porphyry are varieties of this rock, and are much admired for their beauty. Pompey's Pillar and the famous obelisks at Alexandria, called Cleopatra's Needles, are constructed of the red Egyptian granite. The first of these structures, although it is eighty-eight feet high, and nine feet in diameter at the base, is formed of only three pieces. Granite constitutes some of the loftiest mountain-chains of the Eastern Continent, and is abundantly distributed over the north-eastern part of America. "The hardness of this rock, and the great expense of working it to a smooth surface," says Herschel, "prevent its general use as a building material."

Sandstone is easily worked, and, when sufficiently solid, forms an excellent building stone. Some varieties harden on exposure to the weather, and often present a fine clouded appearance when the surface of the slab is smoothed. Sandstone is widely diffused throughout the globe, and is abundant in various parts of the United States. Extensive quarries of the finest quality occur at Portland, Connecticut, which furnish large supplies for the Atlantic States.

Calcareous Rocks, such as the marbles, oolites, nummulitic and magnesian limestones, and the firmer portions of the chalk formation, constitute, with sandstone, the best resources of the architect, since they admit of being easily quarried and sawn into shape.

These formations are very extensively distributed, and are largely employed for building purposes. Paris is built of calcareous rock; some of the pyramids of Egypt are constructed of nummulitic limestone; and the grandest monuments of ancient Rome are made of *travertine,*—a calcareous deposit found along the base of the Apennines.

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7. Are natural arches numerous? How are they formed? Describe the Natural Bridge of Virginia. Those of Iconoza. Give an account of the Inca's Bridge and that of Nahr el Leben.

What is the subject of Chapter IX.? 1. How are the chief mineral products of the globe classified? What are the principal minerals employed as building materials? 2. What are the uses of granite? Where is it found? What prevent its general use? What makes sandstone an excellent building material? Is it rarely found? What fine quarries occur in Connecticut? What calcareous rocks are used for building? Give instances of structures built from this formation.

Throughout the Mississippi Valley limestone is extensively employed as a building material. Marbles are widely distributed, and have from the remotest ages furnished the architect and sculptor with materials of great elegance and beauty. Southern Europe is noted for the fineness and variety of its marbles. The best are those of Pentelicus and of Paros, which have embodied the immortal conceptions of Grecian genius.

Many of the marbles of the United States are of rare beauty, as those of Tennessee and California; and the fine grain and snowy whiteness of a variety of the Vermont marble have caused it to be prized by the sculptor. Calcareous rocks also furnish lime, the chief and most indispensable material for mortar and cement, which are of the first importance in the erection of stone structures.

Slate such as is used for roofing is generally found imbedded in slate rocks of a coarser kind. The finest slate quarries in Great Britain, and probably in the world, are those of Penrhyn, in North Wales. Quarries of excellent slate are found in Pennsylvania and Vermont.

PRECIOUS STONES.

3. The principal gems are the *Diamond, Ruby, Sapphire, Emerald, Opal,* and *Garnet.*

Diamonds are mostly found in a gravelly soil and in the beds of rivers. In the Eastern Continent, the celebrated mines of Golconda in India have produced many splendid diamonds; and they have also been discovered in Borneo, where one was found which weighed 1130 grains and is said to be the largest in the world. Diamonds likewise occur in Central Asia and in the Ural Mountains. In the Western Continent, Brazil is famous for these costly gems, and furnishes most of the diamonds of commerce. In 1822, diamonds to the value of £3,000,000 were found in Brazil.

The Ruby and the **Sapphire** are chiefly found in Ceylon, in the beds of streams; but the finest occur in the Capellan Mountains, in Pegu. The gravel of the brooks in Birmah contains the *Oriental star* and *opalescent* rubies; but the *spinelle* ruby is found in a region five days' journey from Ava: it also occurs in Brazil. Birmah is likewise rich in blue, green, yellow, and white sapphires.

Emeralds of rare beauty occur in Colombia, South America, in Upper Egypt, and in the valley of Tunca at Santa Fé.

Opals of the finest quality come from Mexico, Hungary, and Bohemia. Those which are most prized are opaque, of a pale-brown tint, and shine with a very brilliant iridescence.

Garnets are found in Ceylon, in the Hartz Mountains, and in many other localities; but the most beautiful occur in Bohemia and Hungary.

The inferior gems, such as agate, chalcedony, topaz, carnelian, beryl, and amethyst, are very widely distributed. Topaz, beryl, and amethyst are abundantly found in Brazil and Siberia. Agates of rare beauty occur in Central Asia, and exist in profusion on the shores of Lake Superior. The greater part of the agates, carnelians, and chalcedonies used in Europe come from Oberstein in the Palatinate.

METALS.

4. The metallic products of the globe are of the utmost importance to mankind, inasmuch as they furnish the materials for machinery, tools, and utensils; for objects of convenience, ornament, and luxury; for coin, for medicinal purposes, and for other objects. Metals are very abundantly diffused throughout the world; and there are few regions of any extent which do not possess some of them.

A small number are found in a pure state; but in general they exist in the form of ores, in which the metal is chemically combined with other substances. It is usually deposited in veins, or fissures of the rocks; but a few metals, such as gold, tin, iron, and copper, are disseminated, though rarely, through the rocks themselves.

The chief metals of the globe are *Gold, Silver, Platinum, Iron, Copper, Tin, Lead, Mercury, Zinc, Nickel, Antimony, Bismuth, Manganese,* and *Arsenic.* The first three are termed the precious metals.

5. **Gold** is found in almost every country, but often in such minute quantities that it does not defray the expense of working. It occurs, for the most part, in a native or pure state, disseminated in nodules and threads through many kinds of rock, but principally in quartz: it is found also in the form of scales and grains amid the sands of rivers. Sometimes it is combined with silver, and also with iron pyrites, which is composed of sulphur and iron.

In Europe, the mines of Transylvania and Hungary, the northwest districts of Austria, and the bed of the Danube, unitedly yield an annual product of 60,000 ounces of gold. Small quantities are also found in Spain. In Asia, at the base of the Ural Mountains are very rich deposits of gold; in 1826 a mass of pure gold was here discovered, weighing twenty-three pounds. Gold abounds in the Altai Mountains, in those of Farther India, and in the islands of Japan and Borneo. Thibet and China also produce this precious metal.

Africa has for a long period yielded rich supplies of gold. The most celebrated of its auriferous regions is a portion of the Kong Mountains, where the gold stratum is from twenty to twenty-two feet in thickness, increasing in richness with its depth. Most of the streams from the highlands of Africa bring down gold; and throughout extensive districts large quantities of gold-dust are obtained by washing the sands of the river-beds.

Australia is exceedingly rich in gold. Previous to the year 1851 the existence of this metal in the island was known, yet it had not been obtained in large quantities; but in that year the gold-fields were discovered, and shipments of gold made to England. In July, 1851, a block of auriferous quartz, a foot in diameter, was brought to Sydney from a locality near the Macquarie River. It weighed seventy-five pounds, and yielded sixty-five pounds of pure gold. According to official reports, the entire product of the Australian gold-fields, from their discovery to the close of the year 1866, is 32,377,454 ounces of gold. This amount, reckoning the ounce at twenty dollars, is equal in value to $647,549,080.

The gold-regions of Australia are situated in the southern portion of the island, along the base of the Blue Mountains, the richest mines occurring in the provinces of New South Wales and Victoria.

In the Western Hemisphere gold is found in immense quantities. The most westerly chain of the Andes in Colombia abounds with this metal, and it is found in the sand and gravel of the table-lands of the Andes and in the soil of the eastern plains. Nearly all the streams that descend to the east from the Andes wash down gold; and Brazil is celebrated for the richness of its gold-fields.

What kind of calcareous rock surpasses all others in beauty? What is said respecting it? What additional use of lime-rock is mentioned? To what uses is slate applied? Where are the best quarries situated? 3. Do precious stones occur in numerous localities? Name the most costly gems. What is said respecting the diamond, ruby, and sapphire? Where are emeralds found? Give an account of the opal and garnet. What is said in respect to the inferior gems? 4. Why are metallic products of the greatest importance? Are metals widely diffused? In what state are they found? What are the chief metals? What are the precious metals? 5. Give an account of the distribution of gold, and of the state in which it is found. Mention the principal gold localities in Europe and Asia. Mention the gold localities in Africa. Give an account of the Australian gold-fields. Describe the gold-fields of the Western Hemisphere.

In the United States it is found in considerable quantities in a belt of land stretching from Georgia to Nova Scotia and Canada, and occurs in North Carolina within an area of 1000 square miles, in grains and masses.

Central America and Mexico also abound in this precious metal. But all other gold districts are surpassed in richness by the auriferous zone extending northward from Mexico as far as Behring Strait, embracing among others the gold-fields of California, Colorado, Idaho, and Nevada. In the year 1866 a mass of gold three feet long, and nearly pure, was taken from a quartz-mine near Placerville, in California.

6. **Silver** occurs in many localities throughout the Eastern Continent. Anatolia, Armenia, Thibet, China, Cochin China, and Japan, all produce this metal. Among the richest silver-mines are those of Hungary and Sweden, which are equalled, if not surpassed, by the argentiferous deposits of the Ural and Altai Mountains.

But the Western Hemisphere far exceeds the Eastern in its yield of silver, which chiefly occurs in South America, amid the heights of the Andes. One of the richest regions is that of Copiapo in Chili, where silver was first discovered in 1832 by a native, who, upon casually pulling up a shrub, found a large mass of pure silver beneath the roots. Within four days after the discovery, sixteen veins were found, and lumps of pure metal were gathered from the surface of the soil: a single mass was obtained which weighed 5000 pounds. These mines extend over an area of 150 square leagues. In Peru, silver occurs along the whole range of the Andes from Caxamarca to the Desert of Atacama.

The richest mines of the present time are those of Pasco, which have been worked from the beginning of the seventeenth century. The mines of Potosi and Chota are also celebrated. The metal in these regions lies near the surface, and in the latter district threads of silver are even entwined in the roots of the grass. In the mines of Huantajaya, near the Pacific, masses of pure silver have been found, one of which weighed 800 pounds.

This precious metal occurs in Central America, and in the western auriferous zone of the United States, being found in California, New Mexico, Arizona, Nevada, and other regions.

Silver is very generally combined with lead, and a large quantity is extracted from the latter metal. In 1821, 32,000 ounces of silver were obtained from a single lead-mine in England.

It was remarked by Humboldt many years ago that most of the gold and silver of the globe occurs in mountain-ranges which have a northerly and southerly direction; and the mineral treasures of the Ural Mountains, of the Andes, and of the Alleghanies then evinced the correctness of his opinion. But the theory has since been remarkably corroborated; for the rich auriferous deposits of Australia lie at the foot of the Blue Mountains, which have a northerly and southerly range; and the boundless treasures of gold and silver in the Western United States are found in the Rocky Mountain chain, which follows the same general direction.

7. **Platinum** is a rare but extremely useful metal; and, but for the utensils formed of it, chemistry could not have attained its present state of improvement. It occurs chiefly at Matto Grosso in Brazil, at Choco in Colombia, at St. Domingo, and on the European side of the Ural Mountains. Platinum always exists in connection with a peculiar class of other metals, as palladium, rhodium, and iridium. The largest nugget of platinum hitherto discovered was found in the mines of Choco, and weighed twenty-five ounces.

8. **Iron,** the most useful of all the metals, is diffused throughout the world in immense quantities. This metal is very abundant near the river Viliui in Siberia, and in portions of the Altai and Ural Mountains. In the latter is situated the mountain of Blagod, which rises 1534 feet above the sea, and consists of a mass of magnetic iron ore. Sweden, Norway, Lapland, Russia, Germany, Styria, Belgium, France, and England are all rich in iron. Whole mountains of iron occur in Lapland. This metal is likewise profusely distributed throughout Northern China, Japan, India, and Eastern Asia.

The Western Continent is also rich in iron. In Chili the mountain of Pumachanche consists almost entirely of magnetic iron ore; and in Brazil the mountain of Itabira, 5250 feet high, is composed of pure oxide of iron. Immense quantities of iron exist also in the United States. Iron Mountain and Pilot Knob, in Missouri, are among the richest deposits of iron in the world, and are exceedingly productive. It is found in the Rocky Mountain ranges, vast beds occur in the Atlantic States, and rich localities exist in other parts of the Union.

PILOT KNOB.

9. **Copper,** like iron, occurs all over the globe. Nearly every country in Europe produces it, Africa yields it, and it is found abundantly throughout Asia. Siberia is extremely rich in copper, where it exists both in a pure state and in the form of *malachite*, or carbonate of copper, which is an exceedingly beautiful ore and is regarded almost as a gem. Copper-mines of great value exist in Cornwall, in England, which have been worked from a remote antiquity. But by far the richest of all the copper deposits hitherto discovered occurs in a region south of Lake Superior. Vast quantities of copper exist here in a pure state, and in masses of enormous weight. In the Cliff Mine single blocks have been found from sixty to eighty tons in weight. Copper is also abundant in California and Tennessee and in numerous other localities.

10. **Tin** is produced in comparatively few places. The rich tin-mines of Cornwall, in England, have been worked from very remote times; for it is certain that the Phœnicians resorted to Britain for

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6. Where does silver occur in the Eastern Continent? How does the Western Hemisphere compare with the Eastern in its deposits of silver? Describe the silver-mines mentioned in the text. With what metal is silver often combined? What was the view of Humboldt in respect to the arrangement of the gold and silver deposits of the globe? Has it been verified? 7. Give an account of platinum.

8. What is said respecting the diffusion and abundance of iron? Mention the localities and facts cited. What is said respecting the richness of the Western Continent in iron? What iron mountains are here found? 9. What is said of the diffusion of copper? Mention some of the localities of this metal. What region is now the richest in copper? 10. Give an account of tin.

their supplies of tin. Saxony is rich in tin, and it occurs in Bohemia, France, and Spain. The best comes from the isle of Banca, near the peninsula of Malacca; and an exceedingly rich deposit occurs at Tenasserim, in the Malayan Peninsula. Extensive beds of tin occur in Siberia near the Desert of Cobi; and it is also found in Chili and Mexico.

11. **Lead** abounds in Europe, but is comparatively scarce in Asia. England, Spain, Saxony, Bohemia, and Carinthia are rich in lead. Peru, Mexico, and California likewise produce this metal; and immense lead deposits occur in Illinois, Iowa, and Wisconsin.

12. **Mercury,** which is of great use in separating silver from its ores, is found in but few regions. It occurs in Idria in Austria, and in the rich mines of Almaden in Spain, which were worked seven hundred years before the Christian era. Twelve hundred tons are said to be annually taken from the Spanish mines. Mercury is also produced in Japan, China, Ceylon, and Mexico, and also at Huancavelica in Peru, the mines of which, now almost abandoned, produced, up to the beginning of the present century, 54,000 tons of mercury.

California includes in its immense mineral wealth vast supplies of mercury. In 1866 the total production of the quicksilver-mines of the world was 85,534 flasks, of which 45,909 came from the California mines. The New Almaden mines of California produced in this year 3000 flasks more than the old Almaden mines of Spain,—the richest in Europe.

13. **Zinc** is a very useful metal, and forms brass when combined with copper. Since the application of voltaic electricity to the arts, its importance has greatly increased. It abounds in England, Scotland, Silesia, Poland, Saxony, and other European countries. Zinc-ores are found in New Jersey, Tennessee, Missouri, and in other parts of the United States.

14. **Nickel** exists somewhat extensively in China and Japan, and also in Saxony, Bohemia, and France. It occurs also in Spain, Silesia, and England, and is found in Chatham, Connecticut, associated with arsenic and cobalt.

15. **Antimony,** which is useful not only in hardening alloys, but is also an important medicine, occurs in Saxony, Bohemia, Hungary, Mexico, and Connecticut, and is found in England in the Cornwall mines.

16. **Bismuth** is employed chiefly as an alloy. Its principal localities are in England, Saxony, Bohemia, Transylvania, Swabia, Norway, France, and Connecticut.

17. **Manganese** is the most useful metal in the chemical arts. Its ores are very widely distributed through the primary and secondary rocks in veins, beds, and irregular masses, in the state of black oxide. It is found in England, Scotland, and Ireland; in the Hartz Mountains; in Norway, Bohemia, and Saxony; and occurs in several localities in Hungary, Moravia, Silesia, and France.

18. **Arsenic** is of almost universal occurrence in combination with other metals. It is used in medicine, and is extensively employed in the arts.

COAL, ROCK-SALT, AND SULPHUR.

19. **Coal,** one of the most useful of the minerals, has been beneficently distributed throughout the world in greatest abundance. It occurs in England, France, Belgium, and in numerous localities in Asia and Australasia, being found, among other regions, in Asia Minor, India, Borneo, Formosa, Tasmania, and New Zealand.

It is estimated that the coal-fields of Great Britain cover an area of 12,000 square miles, those of the continent of Europe 10,000 square miles, while 8000 square miles is the extent of the coal-regions of Nova Scotia and New Brunswick. But these immense deposits are greatly surpassed by the coal-fields of the United States, which embrace an area of more than 200,000 square miles. According to Professor H. D. Rogers, the amount of coal in the United States is 4,000,000,000,000 tons,—about *fourteen times* as much as exists in the united areas of Great Britain, France, and Belgium.

The chief kinds of coal are *anthracite* and *bituminous*, under which divisions there are many varieties. The value of coal and iron can hardly be overestimated, when we consider the rapid increase of railroads and of steam navigation at the present time.

20. **Rock-Salt** generally occurs in thick beds, either upon the surface, as in Africa, or at great depths, as in the Polish mines at Wieliczka. Sometimes it is found at great heights above the sea, as in Savoy and in the Andes.

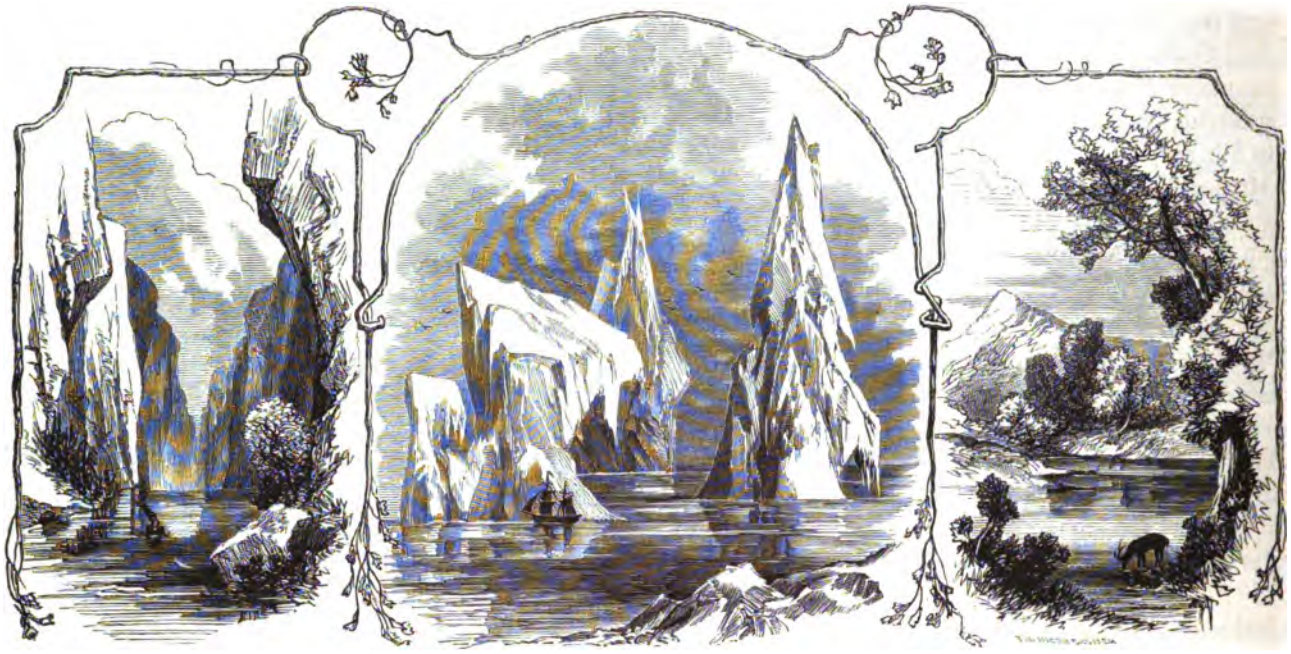
Immense quantities of rock-salt are found at Wieliczka. The mines are worked in lanes or galleries, which have been extended so far that their united distances are fully eight miles. In one of these galleries a chapel, thirty feet long, twenty-four feet wide, and eighteen feet high, with all its columns, altars, and statues, is cut out of the solid salt.

In the valley of Cardona in the Pyrenees, two immense beds of salt, of unknown depth and of great purity, occur in a cliff four or five hundred feet high. In Afghanistan a road is cut out of rock-salt, at the foot of precipices one hundred feet in height, formed of this mineral. The island of Ormuz, at the entrance of the Persian Gulf, is a rock of salt.

BEDS OF ROCK-SALT AT CARDONA.

21. **Sulphur** is chiefly obtained from the volcanic districts of both continents. Large supplies are procured from the semi-extinct volcanoes, or solfataras, where this mineral is thickly deposited. It exists also in great mountain-like masses, such as the Sulphur Island in the Loo-Choo Archipelago. White Island, near Australia, is a mountain of pure sulphur, 860 feet high.

What are the chief localities of this metal? 11. What is said of the distribution of lead? 12. For what purpose is mercury particularly useful? Is mercury widely diffused? What are the localities of mercury? Is California rich in this metal? 13. Give an account of zinc, its importance, and its localities. 14–16. What is said of nickel, antimony, and bismuth? 17. What is said of the use of manganese? Where are its chief localities? 18. Give an account of arsenic and its uses. 19. Give an account of coal, its amount and distribution. What is the extent of the chief coal-fields? What is said of those of the United States? What is said of the value of coal and iron? 20. Give an account of rock-salt. Describe the localities mentioned. 21. What is said respecting sulphur?



SAGUENAY RIVER. ICEBERGS. LAKE ITASCA.

PART FOURTH.

WATER.

1. **Water,** the liquid portion of the globe, constitutes its second grand division. This fluid consists of hydrogen and oxygen, chemically combined in the ratio, by weight, of one part of the former to eight parts of the latter. It absorbs air and other gases in great quantities, and dissolves the various substances with which it comes in contact to such an extent that in its natural state it is never pure. Its taste is affected by these foreign ingredients, that also impart to it an odor which man may fail to detect, but which animals readily perceive; for at a great distance in the desert camels recognize the scent of water.

Pure water can be obtained by distillation, and is tasteless and inodorous. As the blood is the life of all animal existence, so water is the vital fluid of the organized globe. It circulates through the land and air, combining with matter in an infinite variety of modes, and permeates all organized forms. It is above, beneath, around, and within us, and ministers in countless ways to the life and well-being of the world.

The waters of the earth are divided into three principal systems,—namely, the *Land*, *Oceanic*, and *Atmospheric Systems*. Each of these is governed by its own laws; but all combine to form a wonderful mechanism by which the waters move in a ceaseless circuit. From the ocean the sun raises by evaporation immense quantities of water, which are stored in the atmosphere in the form of invisible vapor. This moisture, borne by the winds over the land, descends in rain and snow upon the surface, causing, on the mountains and plains, fountains to burst forth, which, growing into brooks and swelling into rivers, return at length to the parent sea.

The subject of water will be discussed in this part of Physical Geography under the two divisions of the *Land* and *Oceanic Systems*. The *Atmospheric System* will be unfolded in the department of Meteorology.

LAND SYSTEM.

2. The waters of this system are distinguished for their freshness, and are comprised under the three heads of *Springs*, *Lakes*, and *Rivers*.

CHAPTER I.

SPRINGS.

3. **Springs** are either *natural* or *artificial*. Natural springs are those waters which burst spontaneously from the surface of the earth; and their origin is explained as follows:—

Of the vast amount of water that descends from the clouds upon the land, in the form of rain, hail, and snow, one part is evaporated, another part flows at once into the streams, and a third portion is used for the demands of animal and vegetable life. The rest is either absorbed by the soil, or sinks through porous beds of earth or rocky fissures till it meets with impervious strata, such as clay, where its downward progress is stopped. Here the water accumulates in hidden reservoirs, and, increasing in pressure as it rises in height, it at length breaks through the soil at some lower level as a sparkling spring. The strength, permanence, and nature of the fountain will depend upon the amount and supply of water, and the nature and condition of the soil through which it passes.

Dropping Springs.—The subterranean waters, as they emerge into light, do not always gush forth in a single stream, but are sometimes found percolating through precipitous hills and cliffs, and trickling down their sides in minute threads and drops. Such fountains are termed *Dropping Springs*. One of this kind was discovered

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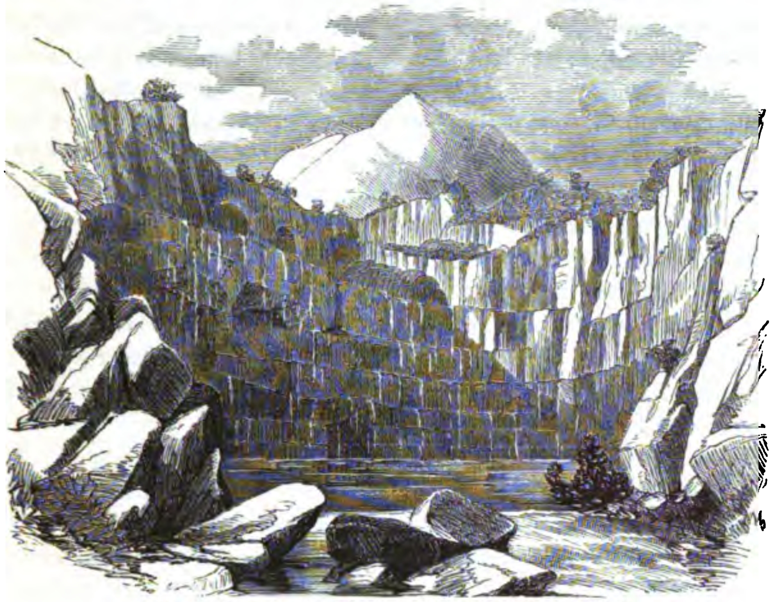
1. What constitutes the second grand division of the globe? Of what does it consist? What is said of its solvent properties? Its taste and smell? What is said of its importance and diffusion? Under what three systems are the waters of the globe classified? What is said of these systems? What systems are discussed in Part Fourth? What one will be treated of in a future chapter? 2. What is said respecting the waters of the land system? How are they classified? 3. What are springs? What is their origin? What are dropping springs?

in Chinese Tartary by Mr. Atkinson, who describes it as follows :—

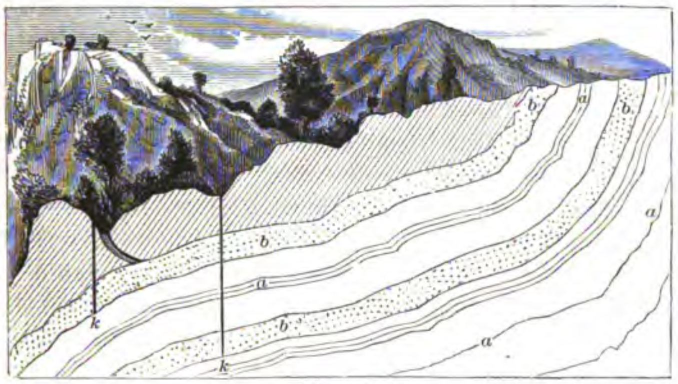
"Returning towards the plain by another route, we visited the Tamchi-Boulac, or the Dropping Spring;—and a magnificent one



TAMCHI-BOULAC, OR, DROPPING SPRING, IN CHINESE TARTARY.

it is. It lies at the foot of the Alatau Mountains; the water comes trickling out of the rocks in thousands of little streams that shine like showers of diamonds; while the rocks, which are greatly varied in color, from a bright yellow to a deep red, give to some parts the appearance of innumerable drops of liquid fire. The water drops into a large basin, and runs over fallen masses of stone in a considerable stream."

Artificial Springs.—The subterranean bodies of water already mentioned may not unfrequently rest upon *inclined* beds of rock, or impervious strata; and similar materials may likewise enclose them, except at the upper end. When this is the case, if an orifice is bored through the crust of the earth till the reservoir is reached, the water will rise through the opening to seek its level; and, if the surface of the under-ground lake is higher than the mouth of the orifice, the water will either flow out in a continuous stream or burst upward in a jet, forming an artificial spring. The force and permanence of the stream will of course depend upon the head and supply of water. Such springs are termed Artesian wells, for reasons already given.



ARTESIAN WELL.

The preceding cut explains the principle of Artesian wells. Let *aa* represent porous strata through which water descends, *bb* strata impervious to water, enclosing the former, except at the top. The water having accumulated in *aa*, and orifices having been bored through the impervious superincumbent strata at *kk*, streams will rise through the openings, forced up by the pressure of the water in the reservoir, and form artificial fountains.

Springs of this kind ascend from an immense depth, and often afford a large and unfailing supply of water. The celebrated well of Grenelle in Paris was commenced in 1834. In 1839 the boring had reached the depth of 1600 feet without striking water; but when the depth of 1800 feet was attained, a stream ten inches in diameter rushed forth, which discharges 500,000 gallons every twenty-four hours. At St. Louis, Missouri, is an Artesian well 400 feet deeper than that of Grenelle.

By means of Artesian wells, "streams are made to break out in the desert, and the thirsty land to become springs of water." In May, 1856, a well of this kind was commenced in the Sahara, in the province of Constantina, under the direction of the French engineers. On the 19th of June of the same year, water was reached, which gushed forth in a copious stream at the rate of 1000 gallons a minute. The joy of the natives was indescribable. The news of this miraculous flow of water spread rapidly through the country; and the Arabs flocked from afar to see this wondrous spring, to which their religious teachers, with solemn rites, gave the name of the "Fountain of Peace."

4. **Different Kinds of Springs.**—Springs are divided into the following classes,—namely, *Constant, Variable, Periodical, Thermal, Mineral,* and *Petroleum Springs.*

5. **Constant.**—Springs of this kind flow continually, and suffer little or no diminution in their volume during the longest droughts. It is supposed that they have their sources in subterranean lakes so vast that the uninterrupted flow of the fountain cannot drain them during the dryest seasons; and at the close of these they are again replenished. Of this character is the famous spring of St. Winifred, at Holywell, in Flintshire, England,—one of the finest in the world. Eighty-four hogsheads of water are computed to issue from this well every minute. It has never been known to fail, though its volume is affected by drought.

6. **Variable.**—Many springs burst forth at first with great violence, then gradually diminish, and at length disappear, to be renewed in strength and volume, passing continually through the same changes at irregular intervals. They are evidently dependent upon the character of the seasons, swelling after heavy rains and diminishing and failing during droughts.

Springs of this nature are common in England, in the chalk vales of Wiltshire and Dorsetshire,—this region being well watered during one part of the year and completely dry at other times.

7. **Periodical Springs.**—Springs of this class swell and subside at stated periods, more or less regular. Some flow and ebb at short and regular intervals during the day, while others occupy in their changes longer and variable periods.

Periodical springs are by no means common. One of the most

Describe the Dropping Spring of Tartary. What are artificial springs? By what other name are they called? Explain from the diagram the principle of Artesian wells. Give the instances cited. 4. What are the different kinds of springs?

5. Describe constant springs. Give the instances cited. 6. What are variable springs? How do they originate? 7. What are periodical springs? Give the instances cited.

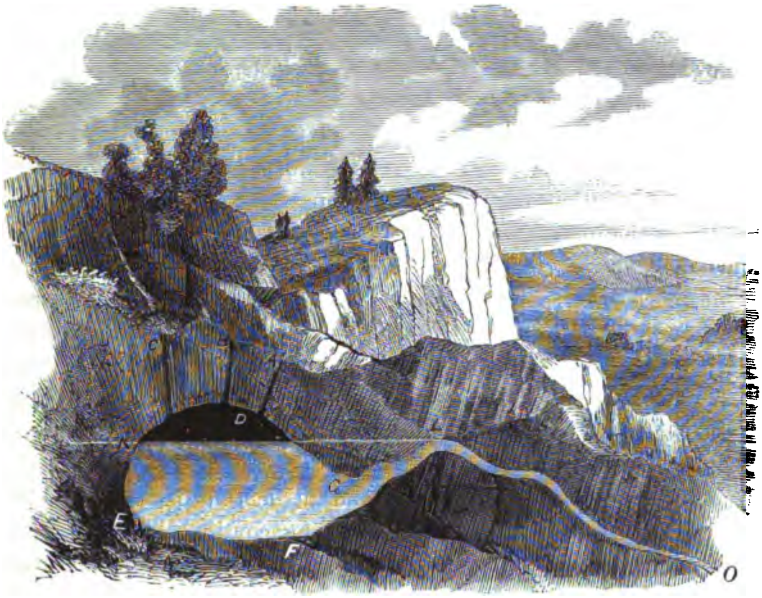
remarkable is the Nebâ el Fûârr, which is situated near the great convent of Mar Jirius, in Palestine, and is thus described by Dr. Thomson in "The Land and the Book:"—

"The Nebâ el Fûârr throws out at stated intervals an immense volume of water, quite sufficient to entitle it in this country to the dignified name of river. It is now quiescent for two days, and active during a part of the third. The cave out of which the river flows is at the base of a hill of limestone entangled in a vast formation of trap rock. It was a day of rest when I examined the fountain; but evidently a large volume of water had rushed along the bed of the river only a few hours before."

Dr. Thomson regards this fountain as the famous *Sabbatic* river, which, according to Josephus, rested during six days of the week and flowed on the seventh. The difference in the present and former periods of ebb and flow may be attributed to the changes to which the spring has been subjected during the lapse of eighteen hundred years.

At Paderborn, in Germany, is a fountain of this kind, which disappears twice every twenty-four hours, returning with considerable force after resting for six hours.

Near Rogersville, in Tennessee, is a periodical spring, which begins by throwing out at once a large volume of water, forming a brook ten feet wide and four or five inches deep. The stream is quickly expended, and its bed left bare for nearly half an hour, when the flow again suddenly commences.



AN INTERMITTENT SPRING.

The origin of periodical springs is usually explained as follows. Let the annexed figure represent a vertical section of a subterranean reservoir, with its enclosing rocks and soil. DKEFG is the reservoir; A, B, and C, fissures in the rocks and soil, through which water flows into the reservoir; GLO is a curved channel extending from the reservoir to the surface of the ground. When, through the conduits A, B, and C, water has flowed into the reservoir till it is filled to the line LK, up to the top of the curved channel, the latter acts as a siphon, and a stream of water issues at O. This stream will continue to flow until the water in the reservoir sinks to the mouth of the channel at G, when it will cease, and will not be renewed till the reservoir is again filled up to the line LK. It is evident that the intervals of ebb and flow will depend upon the size of the reservoir and the relative supply and discharge of the water.

8. **Thermal Springs.**—Ordinary springs, which have their origin just below the limit of frost, possess a temperature almost identical with the mean annual temperature of the atmosphere of the region where they are found; but others exist which follow no such law, but range from the mean temperature up to the boiling-point. They are supposed either to well up from an immense depth, where the internal heat of the globe is very great, or else to derive their warmth from subterraneous chemical action.

Near Little Rock, in Arkansas, is a group of eighty hot springs, which burst out from the side and base of a mountain, forming a stream sufficient to turn a mill. The temperature of the water is 150° Fah. Within ten feet of one of these hot springs is a cold spring having a temperature of 50°. "From this," says a traveller, "a cool draught can be taken, and from one of the others a cooked egg,—as I have frequently seen done."

The proximity of hot and cold springs is not uncommon. A remarkable instance of this kind was observed by Lieutenant Wilkes at one of the Feejee Islands. On landing, the beach was found steaming, with water oozing through the gravel, which in some places was too hot for the foot. It proceeded from five springs, which filled a basin forty feet in diameter, whose water had a temperature ranging from 200° to 210° Fah. A rivulet having a temperature of 75° Fah. flowed close to the basin.

East of the Cascade Mountains, in 40° 39′ 46″ north latitude, Lieutenant Frémont discovered a basin several hundred feet in circuit, filled with hot water. Within a circular space fifteen feet in diameter the water boiled up at irregular intervals with much violence: its temperature near the margin of the basin was 208° Fah.

Magnificent hot springs are found in Australia. Lake Rotomahana (*worm lake*), situated in the Auckland Lake district, is heated at the centre to 104° Fah. by the numerous thermal springs that rise from its bottom and along its banks. The Tarata, the finest of these springs, forms, at the northeastern end of the lake, a noble basin eighty feet long and sixty feet broad, filled to the brim with clear, boiling water, which rises in the centre in a massive column several feet higher than the surface of the basin. In the vicinity of the lake are twenty-five large hot springs, besides many small ones.

But the most wonderful fountains of this class are those of Iceland. They occur in various parts of the island, but are mostly found in a plain thirty-six miles from Mount Hecla. Here, within a circuit of two miles, are more than one hundred springs, some of which boil incessantly without any flowing, but others stream upward in lofty jets. The most remarkable of these fountains are the Great Geyser and the New Geyser,—so called from the Icelandic word *geysa*, signifying to "*burst forth with violence.*"

The Great Geyser is situated within a large circular mound, formed of the silicious deposits of the spring. Upon ascending this mound, when the fountain is at rest, a basin fifty feet in diameter is beheld, filled to the depth of four feet with hot water, clear as crystal, and gently bubbling. In the centre is an opening eighty feet deep, and from eight to ten feet in diameter, which, widening out at the top like a funnel, forms the basin. But the fountain is not long in repose; for the Geyser is an intermittent hot spring. Small jets,

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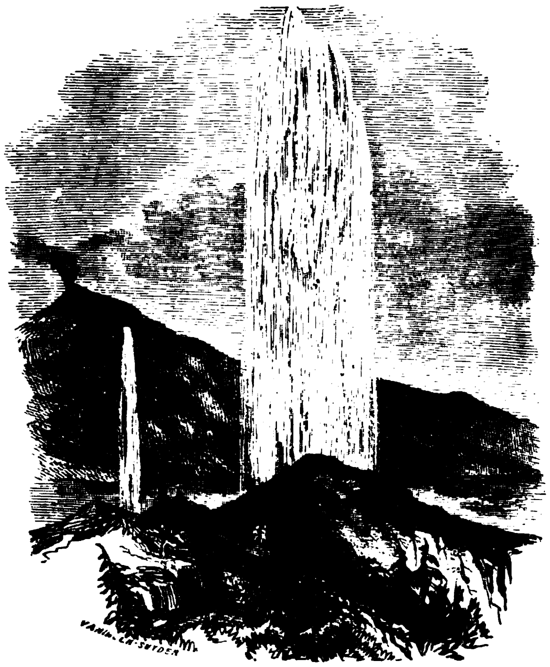
Explain the phenomena of periodical springs. What is said respecting ordinary springs? 8. What are thermal springs? Describe those which are mentioned.

twenty feet in height, frequently occur; but the principal eruptions take place after intervals of about a day. They are announced by loud explosions like the discharge of cannon. Soon the water of the basin becomes greatly agitated, and boils furiously, when suddenly it is projected into the air in a succession of jets, increasing in volume and height until at last it rushes upwards in a torrent, forming a lofty and magnificent column enveloped in rolling clouds of steam. The heights of the jets vary with the changing power of the Geyser. In the time of Olafsen they rose to the altitude of 360 feet. In 1804, Lieutenant Ohlsen, a Danish officer, measured the height of the column by a quadrant, and found it to be 260 feet; while in 1810 the fountain was observed, by Sir George Mackenzie, to ascend no higher than 90 feet.



GREAT GEYSER, ICELAND.

According to Sir John Herschel, there can be no doubt that the waters of the Geysers traverse a bed of lava not yet cold; and he also remarks that a simple and perfect imitation of their phenomena is produced by heating the stem of a tobacco-pipe red-hot and then holding it horizontally while the bowl is filled with cold water.

Hot springs are found in all parts of the world. Near Macao three hot springs occur. At Brusa, in Asia Minor, a fountain bursts forth scalding-hot. Streams of a like character gush from the sides of the Himalayas, and from the volcanic soil of Japan; and at Yakoutsk, in Siberia, hot springs well up from the frozen soil. The "Hot Wells" at Bristol, in England, are known to have been constantly flowing for a period of about two thousand years.

9. **Mineral Springs.**—On account of the great absorptive power of water, all springs are more or less charged with mineral matter; but when they are so strongly impregnated as to produce a sensible effect upon the animal system, they are termed *mineral springs*. Of these there are five principal classes, designated according to the prevailing ingredients they contain:—namely, *Chalybeate*, *Saline*, *Silicious*, *Alkaline*, and *Sulphurous Springs*.

Chalybeate (or iron) springs frequently contain so large a quantity of this metal that they encase the channels through which they pass with a yellow ferruginous deposit.

Saline springs, both natural and artificial, and which produce common salt, exist in various parts of the world. Those of Norwich, in England, rise through beds of rock-salt, and are so richly impregnated that they yield an annual supply of 40,000 tons.

Among the most noted in the United States are those of Syracuse in New York, and of Abingdon in Virginia. Other springs of this class contain salts of magnesia, of lime, and of various other minerals, and are extensively used for medicinal purposes.

Silicious springs hold silex, or flint, in solution. They are very rare, being found only in connection with volcanic rocks. The Geysers of Iceland, as we have seen, are springs of this class; also those of Pinnarkoon and Loorgootha, in India.

Calcareous fountains are those that are impregnated with lime. Of all minerals, lime, in combination with carbonic acid, abounds most in springs. The hot springs of Vignone, in Tuscany, deposit every year a layer of solid matter six inches thick. At Hierapolis, once a flourishing city in Asia Minor, but now in ruins, the warm springs that burst from the neighboring cliffs are said, by ancient writers, to have been so highly charged with mineral matter that when their waters were conducted through the vineyards and gardens, the channels became long walls, each consisting of a single stone. At present a strong spring exists, which branches out into numerous rills, and a limestone cliff has been formed by the mineral depositions.

Sulphurous springs are highly charged with sulphuretted hydrogen, and are readily detected by their offensive odor. Virginia is noted for springs of this kind.

The mineral springs that are efficacious for medicinal purposes, and which are very widely diffused, are impregnated with a variety of ingredients,—one fountain holding in solution a number of minerals more or less different from those which give character to the water of another. Natural fountains of health have been thus provided for the relief and cure of the various diseases that afflict mankind.

Among the most celebrated mineral waters are those of Carlsbad, Selters, and Spa, on the continent of Europe, and those of Tunbridge and Cheltenham, in England. In our own country the principal mineral springs are those of Saratoga in New York, the Sulphur Springs of Virginia, and the Blue Lick Springs of Kentucky. In Canada, the waters of St. Catherine are much prized.

10. **Petroleum Springs.**—Natural and artificial springs of petroleum, or rock-oil, occur in many parts of the globe. In the Birmese Empire, on the Irrawaddy, are at least five hundred wells, producing annually more than 400,000 hogsheads of petroleum. Numerous springs of this kind occur near Havana, in Cuba; and the whole series of the West India and Windward Islands are noted for fountains of petroleum. It wells up in such abundance in Trinidad as to form a bituminous lake three miles in circumference,—partly solid and partly liquid.

In Texas and California petroleum springs are likewise found. But the most remarkable locality is the so-called Oil Region, situated on Oil Creek, in the northern part of Pennsylvania. Natural oil-springs here occur, and numerous Artesian wells have also been sunk. From some of the latter the oil flows forth spontaneously, and from others it is raised by pumping. The amount of oil obtained in this region is almost fabulous.

In boring for oil, inflammable gas, salt water, and oil rush forth the moment the right vein is struck. Sometimes the stream becomes ignited; and the towering column of flame then presents a magnificent spectacle, burning for days, and even weeks.

How can the phenomena of the Geysers be imitated? What is said as to the wide diffusion of thermal springs? 9. What are mineral springs? Name the chief classes. What is said respecting chalybeate springs? Describe saline, silicious, and calcareous springs. What is said of sulphur springs? What is remarked of medicinal springs? Name some of the most celebrated. 10. Give an account of petroleum springs. What sometimes happens?

CHAPTER II.

LAKES.

LAKE BAIKAL, EASTERN SIBERIA.

1. **A Lake** is a standing body of either fresh or salt water, of considerable size, nearly or quite surrounded by land, and not directly connected with the sea or any of its branches. It bears the same relation to a continent as an island does to the ocean.

Lakes abound in all parts of the earth, but are more numerous on mountains and table-lands than in the plains. The mountain-lakes are, however, smaller than those which occur on the lower levels. Thus, Lake Wuler, on the table-land of Cashmere, and which is one of the largest in those regions, has an area of but forty-five square miles; while Lake Superior, which is only 627 feet above the Atlantic, rolls its waves over an expanse of 31,500 square miles. Lakes are found in greater numbers and of larger size in the northern regions of the two continents than in other quarters of the globe, owing to the fact that far more water is evaporated in the low than in the high latitudes.

GEOGRAPHICAL DISTRIBUTION.

2. There are five great lake-systems of the globe,—three in the Eastern Continent, and two in the Western.

Eastern Continent.

3. The first system of the Eastern Continent comprises a belt of lakes extending through the higher latitudes of Europe and Asia. It begins at Great Britain, and, stretching through Norway, Sweden, and along the south shore of the Baltic, runs thence across Finland, Northern Russia, and Siberia as far as Behring Strait. Lakes Onega and Ladoga, in Russia, the former containing 3280 square miles, and the latter 6190, are among the largest in this system.

The second system—which likewise ranges eastward through Europe and Asia—lies south of the former, following the great mountain-ranges. It embraces the lakes of the Pyrenees, the Alps, and the Apennines, and all those of Western and Central Asia. The Cáspian and Aral Seas, which are truly lakes, are the largest of this system, the former covering an expanse of 145,000 square miles, and the latter 30,000.

The third in magnitude is the celebrated Lake Baikal, in Eastern Siberia, called by the natives the Holy Sea. It lies amid lofty granite mountains, at the height of about 1800 feet above the sea. It is the largest mountain-lake in the world, having an area of not less than 14,000 square miles. Even when the atmosphere is most calm, its waters are seldom without a wave; but when the winds are abroad it is the scene of terrific storms. Connected with this lake is a singular phenomenon: when its surface is most tranquil, a vessel sailing upon its waters is subjected to such severe shocks that it is difficult for the sailors to stand upon their feet. The lake is situated near the centre of an earthquake region; and this effect is attributed to the action of volcanic forces.

The European lakes of this system consist of fresh water; but many of the Asiatic lakes are salt and brackish.

The third lake-system of the Eastern Continent is in Africa, and consists almost entirely of the chain of fresh-water lakes lately discovered by the Nile explorers and by Dr. Livingstone. The most important of these are the Victoria Nyanza, Albert Nyanza, and Tanganyika.

A great interest is attached to the first two, since they are now regarded as the long-sought sources of the Nile. The Victoria Nyanza was discovered by Captain Speke, on the 30th of July, 1859. It extends about 200 miles in a north-and-south direction, and probably 300 miles from east to west; but its eastern limit is not well ascertained. It is 3308 feet above the sea-level, and is crossed by the equator. A stream 500 feet wide, issuing from this lake at its northern extremity, enters Albert Nyanza in 2° 20′ north latitude.

This fine lake was discovered by Mr. Baker, in February, 1864. Its length is at least 350 miles, and its width, for a considerable distance, is 100 miles. It is situated 2720 feet above the ocean, and is enclosed by mountains that rise to the height of 7000 feet above the surface of its waters. A main stream of the Nile runs northward from the northern end of the lake; and from this point the river has been followed to the sea. Lake Tanganyika was discovered by Burton, in 1859. It is south of the Albert Nyanza, and is supposed to be connected with it. It is more than 300 miles long, and, at its southern extremity, is about 60 miles wide.

Considerably to the south of Tanganyika, and at a lower level, Lake Nyassi occurs, which was discovered in 1859 by that dauntless explorer Dr. Livingstone. It exceeds 200 miles in length, and ranges in breadth from 15 to 60 miles. Within this lake-district several other smaller sheets of water are found.

Lake Tchad, in Soudan, is a large expanse of fresh water, the extent of which has never yet been ascertained; but it is known that the kingdom of Bornou stretches for 200 miles along its western shores. The African lakes are commonly shallow, and subject to great fluctuations in size, their limits being widely extended during the rainy season.

What is the subject of this chapter? 1. Define lakes. Are they widely distributed? Are they more numerous in the lowlands than in table-lands? In what latitudes do they most abound? 2. How many lake-systems are there? How many are there in the Eastern Continent? Describe the first system. What is said of Lakes Onega and Ladoga? Describe the position and extent of the second lake-system. Name the largest lakes in this system, and describe them. What singular phenomenon occurs at Lake Baikal? Where is the third lake-system found? Describe the great chain of African lakes. Describe Lake Tchad.

Western Continent.

4. The lakes of the Western Continent far exceed in grandeur those of the Eastern, and are mainly embraced under two systems.

The first extends over the Great Northern Plain, and includes the magnificent chain formed by Lakes Superior, Michigan, Huron, Erie, and Ontario, whose united areas are estimated at 92,000 square miles, and which are supposed to contain more than half of the fresh water of the globe. Lake Superior exceeds all the others in magnitude, having an area of 31,500 square miles. With the exception of Erie, they are all very deep. Lakes Superior and Michigan respectively reach the depth of 900 feet, while Huron and Ontario are each twice as deep. Another portion of this system is the immense network of lakes which spreads throughout British America and extends to the Arctic Ocean. Among the largest of these are Athabasca, Winnipeg, and Great Slave and Great Bear Lakes, which range in their areas from 3000 to 19,000 square miles.

The second system runs from the Columbia on the north to Panama on the south, occupying the table-land of the great western mountain-chain. It comprises the lakes of Utah, Mexico, and Central America, none of which are of great size. The largest, Lake Nicaragua, has an area of 3500 square miles. Great Salt Lake contains 1875 square miles; and Lake Chapala, in Mexico, 1000 square miles.

Few prominent lakes of any size are found in South America. The most noted is Lake Titicaca, in Bolivia, which is situated at the height of 12,847 feet above the sea, and embraces an area of 4000 square miles.

The lakes at the eastern base of the Andes are transient in their character, being nothing more than marshes and pools in the dry season, but spreading out into vast shallow sheets of water during the rainy period.

The lakes of Australia are of a similar nature, the large lakes being changed in the summer into a series of small ponds. Lake Torrens is probably the most extensive sheet of water in this island. It is from fifteen to twenty miles wide, and was traced by Mr. Eyre, in 1840, through a distance of 400 miles. It is very shallow, and is broken up in the dry season into numerous pools.

Classification.

5. Lakes are divided into four classes, as follows:—

I. Those that have neither outlets nor inflowing streams.
II. Those that have inflowing streams, but no outlets.
III. Those that have outlets, but no inflowing streams.
IV. Those that have both inflowing streams and outlets.

Lakes of the first two classes are usually salt. The last two comprise the fresh-water lakes, which are far more numerous than the salt lakes. Lakes of the first class occur frequently in depressions, which appear to be extinct volcanic craters. Their waters are chiefly derived from deep springs at the bottom, and are swollen at times by the rains, and by the melted ice and snow of the surrounding regions. Lakes of this kind abound in the vast steppes of Northern and Western Asia, and their waters are usually salt. But salt and fresh-water lakes both occur in these plains, even lying together,—a fact which is not fully accounted for. One of the most noted of the lakes that have neither outlet nor inlet is Lake Tulza, which lies north of the range of Mount Taurus. It is fifty miles long, but narrow; and its waters are so salt that fish cannot live in them.

Lakes of the second class, which have no outlets, but into which brooks and rivers flow, are few in number, and, like those of the first kind, are commonly salt. The most remarkable instances of this class in the Eastern Continent are the Caspian, Aral, and Dead Seas, which, though usually called seas, are truly lakes.

The Caspian Sea covers an area of 145,000 square miles, and its surface is eighty feet below the sea-level, while near the middle it is more than 2800 feet deep. It drains in Europe alone 850,000 square miles of surface, and into it flows the Volga, the largest river in Europe, together with the Ural, Kur, Aras, and others. Yet, notwithstanding this immense influx, more water is lost by evaporation than is received, and this sea is gradually diminishing in size. The same is true of the Sea of Aral, into which flow the Sihon and Amoo.

THE DEAD SEA.

The Dead Sea, which is 1298 feet below the level of the Mediterranean, receives the Jordan and other streams. Its waters are exceedingly salt and bitter: crystals of salt were brought up from its bottom, at the depth of 700 feet, by the American expedition under Lieutenant Lynch. The principal salt lakes of the Eastern Continent, besides those just mentioned, are the Lakes of Elton and Urumiyah. The former is situated east of the Volga, and contains an area of 130 square miles: its waters are very salt, and the Russians here obtain their largest supplies of this mineral. The Lake of Urumiyah, on the Persian frontier, is 300 miles in circumference, and its beach is a solid pavement of salt a quarter of a mile broad.

In the Western Continent, lakes of the second kind occur on the table-land of Utah. The largest of these is Great Salt Lake, which has a circumference of 291 miles: its waters are almost pure brine, and are so dense that a person can float upon them without an effort: its rocky shores are encrusted with salt, and its shallow bays are covered with it for miles. Throughout this region saline lakes abound, which receive the waters of a considerable number of rivers and streams.

6. **Origin of Salt Lakes.**—The different salts contained in the mineral crust of the earth are readily dissolved in water; and thus the rains, which, filtering through the soil, gush forth in fountains or pour down into river-beds, become charged with saline matter.

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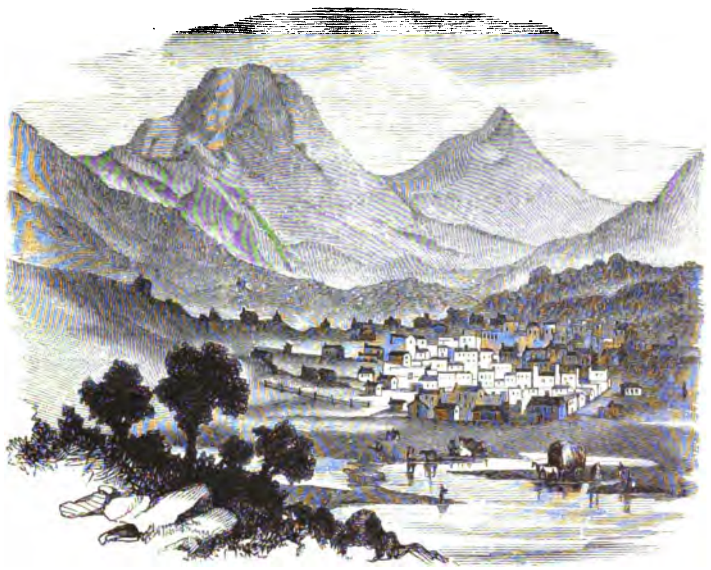
4. How many lake-systems are found in the Western Continent? Where is the first situated? What chain of great lakes does it include? Describe the lakes mentioned. What is the range of the second system? Describe it, with some of its prominent lakes. Are there many lakes in South America? Describe Lake Titicaca. What is the character of the lakes east of the Andes? State what is said of the lakes of Australia. 5. Give the classification of lakes. Where do lakes of the first class frequently occur? Describe them. Where do lakes of this kind abound? What is the character of their waters? What is said of Lake Tulza? What are the most remarkable instances of lakes of the second class? Describe these seas. Describe the other salt lakes which are mentioned. Are there lakes of this kind in the Western Continent? Describe Great Salt Lake. 6. Give an account of the origin of salt lakes.



GREAT SALT LAKE, UTAH.

It is therefore evident that where streams flow into a lake which has no outlet, and which loses by evaporation as much water as it receives, the contained salts must be constantly accumulating, since all the water which is evaporated is pure, and its saline ingredients are left behind. If the evaporation should from any cause at length exceed the influx, these lakes are changed into salt valleys and plains. Some of the largest salt lakes, as the Caspian, Aral, and Dead Seas, occupy basins below the sea-level; but this is by no means a condition of their formation, as saline waters are found at all heights where the above-mentioned causes exist; for on the plateau of Utah salt lakes occur, and also on the table-lands of the Himalayas. In lakes which have outlets no such accumulation of saline matter can occur, and their waters are consequently fresh.

Lakes of the third class, which have outlets, but no streams running into them, are usually situated at high elevations, and have their sources in subterranean springs and in the rains and snow of the neighboring lands. Lake Sir-i-Kol, which is situated on the table-land of Pamir, called the "Roof of the World," belongs to this class. It is the highest lake on the globe, being 15,600 feet above the sea-level, and is the source of the river Amoo. It covers an area of only fourteen square miles; and it receives a never-failing supply of water from the snow-capped mountains which encircle it and rise to the height of 3500 feet above its level.

Lakes of the fourth class, which are both the recipients and sources of streams, far exceed the rest in number. The chain of the great lakes of North America presents the finest instances of this class. An immense number of streams pour into these inland seas, and the surplus waters of the upper lakes, descending the precipices of Niagara, join those of Ontario, and give rise to the majestic river St. Lawrence.

7. **Transparency and Depth of Lakes.**—Many lakes are noted for the purity and brilliancy of their waters. Those of Great Bear Lake are of a light-blue tint, and so clear that a white object can be seen at the depth of ninety feet. Lakes Superior and Huron are remarkable for their transparency, rocks and fish being seen at extraordinary depths; and the waters of Lake George, so famed for its picturesque beauty, possess the same property. But nothing can exceed the transparency of the Norwegian lakes. The voyager appears to be sailing over submerged mountains and plains; and so clear is the water that the shells upon the bottom are perfectly visible at the depth of 120 feet.

Some lakes, though small, are of great depth: such is the Altyn Kool, or Golden Lake, of Siberia,—one of the most beautiful in the world. It occupies a vast chasm in the Altai Mountains, of such profound depth that, according to the soundings of a Russian officer, the bottom in some parts cannot be reached by a line two thousand feet in length. Lake Constance, in Switzerland, is at one point equally deep; while the Lake of Nemi, in Italy, attains the amazing depth of 2700 feet, or more than half a mile.

LAKE OULUNJOUR, MONGOLIA. (As seen from a cave in the surrounding rocks.)

8. **Advantages of Lakes.**—The numerous lakes scattered over the surface of the globe fulfil important purposes in the economy of the world. They serve as vast reservoirs for storing up the superabundant waters of the wintry season against the heat and droughts of summer; and not only do they furnish the supply of water for the outflowing streams, but from their broad expanses they fill the thirsty atmosphere with moisture, and temper the dryness of the surrounding country. Moreover, the numerous rivers and rain-floods that pour into their basins bring down with them the finest portions of the soil, which sinks to the bottom through the tranquil waters of the lake; whilst the constantly-deepening outlets increase the drainage. It thus results in some cases that the lake at length disappears, and is replaced by a fertile vale. The surface of the land has in this way been greatly modified, and many a valley which now teems with the richest verdure was once beneath the waters of a lake.

Nor must we forget the advantages of intercommunication afforded by lakes, of which the vast northern lakes of America furnish the most striking examples; for their waters are the seat of an immense internal commerce.

How are salt plains accounted for? What is said of the situation of salt lakes? Describe lakes of the third class. Mention the instances cited. Describe lakes of the fourth class. Are they few or many? What lakes present the finest examples of this kind? 7. State what is said respecting the transparency and depth of lakes? Mention the instances. What is said of the Altyn Kool, of Siberia? 8. What is said of the uses of lakes?

CHAPTER III.

RIVERS.

1. **Rivers** are inland streams of considerable size, flowing into the ocean, a lake, or another stream. In some cases they are absorbed in sandy deserts: thus, the streams of Central Arabia, which descend towards the Persian Gulf, are lost in the intervening deserts; and the river Desaguadero, that issues from Lake Titicaca in Bolivia, sinks in the vast wastes that lie south of the lake.

2. The principal characteristics of rivers are their *Sources, Basins, Water-Sheds, Courses, Deltas, Velocities*, and *Magnitudes*.

3. **Sources.**—Rivers originate in springs and lakes, or in the ice-fields and glaciers of snow-capped mountains. The waters of several fountains flowing together form a brook; and brooks uniting with brooks, soon swell the stream into a river. Rivers likewise combine, one of the number being regarded as the main stream, while the rest are called tributaries, or affluents. The Abyssinian branch of the Nile springs from a confluence of fountains.

Lakes are a prolific source of rivers, and give rise to some of the mightiest streams of the globe. From the beautiful Lake Itasca springs the noble Mississippi; and in the vast chain of the great northern lakes are the head-waters of its rival, the St. Lawrence. The long-hidden fountains of the Nile are the lately-discovered lakes the Victoria and the Albert Nyanza; and the Volga, one of the largest rivers in Europe, flows from a small lake amid the Valdai Hills.

SOURCE OF THE GANGES.

The enormous glaciers and vast ice-fields that clothe the sides and summits of the loftiest mountains also give birth to grand and important rivers. The source of the Ganges is beneath the glaciers of the Himalayas, 13,800 feet above the sea. From an immense cave in the face of a solid precipice of ice, the sacred stream bursts forth at once a river, more than 100 feet wide. Near this spot a shrine has been erected, to which the Hindoo pilgrim resorts.

The rapid Rhone, one of the chief rivers of Europe, springs from a glacier west of the St. Gothard, 5500 feet above the level of the sea.

4. **Basins.**—The entire region drained by a river and its affluents is called its basin. Each of these tributary rills, brooks, and minor rivers has its own basin; and their united areas constitute the basin of the main stream. The size of a river-basin depends, in general, on that of the great division of the globe to which it belongs. Thus, Europe has the smallest basins, Asia the next in magnitude, and America the largest,—the vast basin of the Amazon, with its network of mighty rivers and subordinate streams, having an area of no less than 1,512,000 square miles.

5. **Water-Sheds.**—The elevated land which divides one basin from another is called a water-shed, or water-parting, inasmuch as the springs and streams here flow in different directions into the river-basins lying on the opposite sides of the ridge. The roof of a house is a common and apt illustration of this feature.

Water-sheds are sometimes formed by mountains, and very often by moderate elevations in the great plains of the globe. Thus, amid the Rocky Mountains, and only a mile or two apart, are the head-waters of the Columbia and Missouri Rivers; and the streams of the Alps find their way to the German Ocean, and to the Black and Mediterranean Seas, through the Rhine, Danube, Rhone, and Po. The region where the Mississippi has its sources presents an example of the other kind of water-shed. A ridge of land here rises to the inconsiderable height of 1680 feet; yet it divides two great basins,—the waters on the north side flowing into the Arctic Ocean, and those on the south into the Gulf of Mexico.

In Eastern Europe, a low rise of land, extending from the Carpathian Mountains to the Valdai Hills, forms a water-shed whence flow the streams that, on the west, enter the Baltic through the Vistula, Niemen, and Duna, and, on the east, those that unite with the Black and Caspian Seas through the Dniester, Dnieper, Don, and Volga. Where the water-parting is low, barges are carried over from one basin to the other; and in some instances the elevation is so slight that a heavy rain will unite the waters of the contiguous basins.

In the region which divides the head-waters of the Mississippi and the Northern Red River, boats are said to pass without interruption from basin to basin when a flood prevails.

There are even examples of river-basins so running into each other that a natural water-communication exists between them. The most remarkable instance of this nature occurs in South America, where the river Casiquiare, 180 miles long, connects the adjacent basins of the Orinoco and the Amazon. It is 100 yards wide where it leaves the Orinoco, and 550 where it flows into the Rio Negro,—a large affluent of the Amazon.

For the purposes of navigation, river-basins are frequently united by canals. The Erie Canal, which is one of the longest in the world, and is the route of an immense inland trade, connects Hudson River with Lake Erie, the natural outlet of whose water is the St. Lawrence. This latter stream is also united to the Mississippi by means of several important canals.

6. **Courses.**—River-courses are usually winding, but vary in their physical features in different parts of the stream. In their upper course the large rivers of the globe generally flow in rapidly-sloping channels, the stream either rushing in foam through narrow gorges over its rocky bed, or leaping from precipices in cataracts, amid clouds of spray. Lower down, in its middle course, a river usually

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Of what does Chapter III. treat? 1. What are rivers? 2. Mention their chief characteristics. 3. What is said of the sources of rivers? Give the illustrations. 4. What is a basin? What does the size of a river-basin commonly depend upon? 5. What is a water-shed? How is it formed? Give the illustrations. What is said respecting river-basins when the water-shed is of small elevation? Are contiguous basins sometimes naturally united? Give the instances cited. How are adjacent basins artificially connected? 6. Describe the phenomena of river-courses.

loses its violence, becomes broader, and, flowing with a more peaceful current, winds among the hills in graceful curves. Sometimes, however, it is here confined between mountain-ranges; and then its former turbulent character is resumed. In its lower course a river generally flows through a plain, its bed being almost level, and the motion of its waters scarcely perceptible. At its outlet it is either discharged as a single current, or diverges into many minor streams.

7. **Deltas.**—Where a river flows through an alluvial region, it brings down to its mouth a vast amount of soil, which is there deposited in its sluggish waters. Marshes, shoals, and islands are thus formed, through which the river, branching into numerous streams, forces its way. The entire network of land and water constitutes a triangular figure, termed a *delta*, from its resemblance to the form of the Greek letter of this name (Δ).

The Ganges, which carries down annually to the sea 534,600,000 tons of solid matter, has formed a delta, called the Sunderbunds, 200 miles long and 180 broad; and the Nile has likewise a delta more than 170 miles in length. The delta of the Mississippi comprises 14,000 square miles, and this great river bears down yearly into the Gulf of Mexico an amount of soil sufficient to cover an area of a square mile to the height of 268 feet.

Deltas are also formed on a smaller scale where a tributary enters the main stream, and at the junction of a river with a lake. Thus, the Volga has a delta at its outlet, discharging its waters into the Caspian through seventy mouths.

8. **Velocity.**—The velocity of a river depends upon the *form of its channel*, its *volume*, and the *inclination of its bed.*

The friction of a stream against the sides and bottom of the channel checks its velocity; and the curves and windings of the banks, by arresting its progress and changing its course, have the same effect.

If these impediments did not exist, the river would be transformed into an instrument of ruin, and rush in a torrent to the sea, the water descending like a falling stone with the accelerating force of gravity. Under this supposition it has been computed that the Rhine, 900 feet below the point where it receives most of its waters, would flow at the rate of 164 miles an hour, and that the Thames would possess a speed of 50 miles an hour.

Where one stream joins another without greatly enlarging its channel, its velocity is accelerated,—a more rapid flow carrying off the increased volume of water.

We have seen that the inclination of the channel of a river is usually greatest near its head-waters, and least in the lower part of its course. On this account, and from the causes of retardation above mentioned, the great rivers of the globe, in their full development, have commonly a very slow motion. The mere pressure of the particles of water upon each other, when they have once received an impulse, is sufficient to prolong the current when its bed has scarcely any inclination.

The Amazon for the last 700 miles of its course falls but one-fourth of an inch for every mile and a quarter; the La Plata for 400 miles from its mouth descends only one thirty-third of an inch per mile; while, according to Major Rennel, the Ganges has scarcely any perceptible fall for the last 1300 miles of its course.

Rapids.—When the perpendicular descent of the channel is more than about one foot for two hundred in length, the swiftness of the river is so great that it is considered unnavigable for sailing-vessels; though higher velocities are overcome by the power of steam. When the inclination is great, *rapids* are caused, around which navigation is conducted by canals. In some cases the flood-tide rises over the rapids in the lower part of a river, thus removing at intervals the obstructions they create.

The famous cataracts of the Nile, which are properly rapids, extend throughout the river for more than 200 miles. They consist of nine or ten sloping descents, which are about a foot in height. The Columbia pours down in rapids to the Pacific, through magnificent rocky gorges. But none exceed in sublimity and grandeur those of the St. Lawrence, the principal of which are the Long Sault and La Chine. In the former, this mighty river descends with tremendous speed for the space of *nine* miles, in one continuous rapid, being divided into two channels by an island. In the southern channel, which is very narrow, a raft is said to drift nine miles in forty minutes. The rapids of La Chine are so swift that a canal has been constructed around them, as vessels are unable to stem the current. The rapids of Richelieu, between Montreal and Quebec, occur at the ebb and disappear at the flood tide, the river rising from the latter cause from fifteen to eighteen feet.

Falls.—When the inclination of the channel of a river is so great that it is nearly or quite perpendicular, *falls*, or *cataracts*, are caused. They occur in every part of the world, and are phenomena of great beauty and sublimity. Some are remarkable for their height, others for their volume of water; while in the finest both these characteristics are combined.

NIAGARA FALLS, NIAGARA RIVER.

Of all the cataracts on the globe, the Falls of Niagara have been regarded as the grandest. The surplus waters of the four great northern lakes form the Niagara River, which, issuing from Lake

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7. What are deltas? What is said of the deltas of the Ganges, Nile, and Mississippi? How are deltas formed on a smaller scale? Give the instance cited.
8. Upon what does the velocity of a river depend? How is the velocity of a stream naturally checked? What would result if these impediments did not exist? What happens when one stream joins another without greatly enlarging its channel? What is said respecting the velocity of great rivers? State the inclination of the beds of the Amazon, La Plata, and Ganges. When do rapids occur? Give an account of those mentioned. How are falls produced? What peculiarities are combined in the finest? What falls have been considered the finest in the world? Describe them.

Erie, descends at first in a series of rapids at the rate of fifty feet in less than a mile, and then plunges over a precipice more than 160 feet high. The river at the falls is about three-quarters of a mile broad, and the precipice curves in the form of a semicircle. Goat Island divides the cataract into two portions,—the American Falls, and the Horse-Shoe Falls on the Canada side. The breadth of the former is 1000 feet, and its height 164 feet; the latter is 2000 feet across, and 158 feet high.

An idea may be gained of the immense volume of water that forms the cataract, from the estimate that in the Horse-Shoe Falls alone 20,000,000 cubic feet of water descend per minute, and that on its very verge the sheet of water is at least eighteen feet thick.

The Victoria Falls on the Zambezi River in Africa, called by the natives the Mosyoantunyo, or *Smoke-Sounding Falls*, vie in magnificence with those of Niagara. They were discovered by Dr. Livingstone in 1855, and were afterwards visited by himself and his nephew, Charles Livingstone. The falls are caused by the descent of the Zambezi into an immense perpendicular crack or chasm formed in a hard basaltic rock. The chasm is eighty yards wide at its narrowest part, and into this abyss the river plunges down, with a deafening roar, to the depth of 360 feet. The falls are broken by several small islands; and from one of these, called Garden Island, situated on the very brink of the fissure, a line was let down and the height of the falls measured. The falling water in its descent encloses a large amount of air, that rushes back up the chasm, driving before it the spray of the falls, which forms into clouds and columns of vapor from 200 to 300 feet high.

When the Victoria Falls were visited by the Livingstones, it was at the close of a drought, when the river was lowest; but even then Mr. Charles Livingstone, who had seen Niagara, deemed them superior in grandeur to the latter. In his opinion, Niagara in general excels the Zambezi in the amount of water, but not when the latter is in flood; while the height of Niagara is but half that of the *Smoke-Sounding Falls*.

VICTORIA FALLS, ON THE ZAMBEZI RIVER, AFRICA.

The wonderful valley of the Yosemite, in California, abounds with many beautiful cataracts, distinguished for their height, the most remarkable of which are the Great Yosemite Falls. These falls are formed by a stream of the same name plunging over a rocky precipice into the valley, 2000 feet, or nearly half a mile, below. The wall of rock has its altitude divided by two ledges, which receive the torrent, breaking it into three falls. The first cataract is 1300 feet high, and from its foot the foaming stream rushes through a gorge of the first ledge, descending by a leap of 250 feet to the next ledge, where it makes its final plunge of 450 feet into the valley beneath.

According to some travellers, the stream of the highest fall is dissipated into spray before it reaches the base; but others, at the same season of the year, have beheld the torrent descending unbroken, and with a well-defined outline.

The Yosemite is a small stream, about equal, at the close of the summer, to three or four ordinary mill-brooks; but it swells to a torrent in the spring, when the sun melts the snows at its source, which fall in the gorges of the mountains to the depth of twenty feet.

YOSEMITE FALLS, CALIFORNIA.

Ranking beneath those just described, but replete with the elements of grandeur and beauty, numerous other falls are found in various parts of the globe. In Italy, the Velino rushes over a precipice 300 feet high, forming the finest cascade in Europe. The Cauvery, the chief river of Southern India, descends, near Seringapatam, in two cataracts of surpassing grandeur, the first being 350 and the other 460 feet high. In Africa, the Tacazze, a tributary of the Nile, receives its name ("terrible") from its many furious cataracts, which vary from 100 to 150 feet in height.

The Falls of Trenton, in New York, are distinguished for their wild and picturesque beauty. Those of the Passaic River, in New Jersey, are 70 feet high; and the waters of the beautiful cataract of Montmorency, near Quebec, descend 250 feet, in one bright and unbroken sheet. Of a sterner character are the Falls of St. Anthony, where the entire Mississippi descends 17 feet; as are also the cataracts of the Missouri, where the great river, after bursting the barriers of the Rocky Mountains, leaps down in a series of rapids and cataracts 360 feet, the three greatest falls having the respective altitudes of 87, 47, and 26 feet.

In South America, near Bogota, the Bogota River, plunging from the height of the plateau through a chasm 30 feet wide, forms at two leaps the magnificent Falls of Tequendama, 574 feet high.

Cañons.—The current of a river is usually only a few feet below the surface of the region through which it passes; but in some

Describe the Victoria Falls, and compare them with Niagara. Describe the Yosemite Falls. Give an account of the other falls which are mentioned.

cases the turbulent waters have worn down channels of immense depth, and flow through narrow rocky gorges, thousands of feet below the general level of the country. This peculiarity in river-channels is termed a *cañon*,—a Spanish word meaning the place of passage of a river between perpendicular rocky walls of great height.

The lofty sides of a cañon not unfrequently overhang their bases, and even form a natural tunnel; and through these confined channels fret and foam the rushing waters, moulding the rocks into a thousand strange and wondrous shapes.

Cañons abound in the region west of the Rocky Mountains, occurring throughout its entire plateaus, and especially at the upper courses and tributaries of the Rio Grande, Snake, and Platte Rivers. But nowhere else are they developed on such a scale of magnificence and grandeur as on the Colorado. Rising from numerous sources ten or twelve thousand feet above the sea-level, on the western side of the Rocky Mountains, this great river descends into the plateau of the same name, through which, in the lapse of ages, it has worn its present wondrous channel, the walls of which sink down perpendicularly to the river from the edge of the table-land, to depths varying from 3000 to 6000 feet, and for a distance of more than 300 miles.

BIG CAÑON, COLORADO RIVER.

The two most remarkable gorges of the Colorado are the Black and Big Cañons. The Black Cañon occurs near the Rio Virgen, where the river cuts through the Black Mountains; and its walls are here more than 1000 feet high. "No description," says Lieutenant Ives, the explorer of this river, "can convey an idea of the varied and majestic grandeur of this peerless water-way. Wherever the river turns, the entire panorama changes. Stately façades, august cathedrals, amphitheatres, rotundas, castellated walls, and rows of time-stained ruins, surmounted by every form of tower, minaret, dome, and spire, have been moulded from the Cyclopean masses of rock that form the mighty defile."

The Big Cañon of the Colorado begins near the mouth of the Diamond River, in 35° 46′ north latitude, 113° 24′ west longitude. At this point its walls have an altitude of 3000 feet. But a few miles farther eastward the table-land rises to the altitude of 7000 feet above the sea, and the vast cliffs of the cañon tower to the height of more than a mile above the stream. The scenery resembles that of the Black Cañon, only it is on a more colossal scale. "It is," says Lieutenant Ives, "the most magnificent gorge, as well as the grandest geological section, of which we have any knowledge. For 1000 feet above the river the cliffs are composed of granite. Next above this are strata of sandstone, limestone, and shale, 2300 feet in thickness; and higher still appear the carboniferous series, more than 2000 feet thick, consisting of limestone, sandstone, and gypsum, apparently all marine, and highly fossiliferous."

9. **Magnitude.**—The size of a river depends upon several causes, the principal of which are its length, the extent of its basin and the amount of the rain-fall and evaporation within the same, and the connection of the stream with snow-capped mountains. Where all these causes combine, the largest streams are found; and they combine in their fullest development in the Amazon,—the mightiest river in the world; for its length is 3600 miles; its basin is about eight times the size of France; the broad sweep of the northeast trade-winds, loaded with moisture, drenches the region which it drains; interminable forests check evaporation from the dank soil; and its sources are hidden amid the snowy heights of the Andes.

The chief affluents of the Amazon are themselves large rivers, varying from 750 to 1800 miles in length. In the upper part of its course it is from one to two miles in width; while its banks where it enters the Atlantic are distant from each other more than one hundred miles. At a distance of 2000 miles from its mouth it is navigable for vessels of any burden; for at the confluence of the Tunguragua and Ucayale, where the Amazon takes its name, no bottom has been found with a line more than 200 feet long. Next in rank is the La Plata, which rolls annually to the sea about half as much water as the Amazon. The Mississippi discharges but one-fourth as much as the latter, though it is the longest river of the world. From the Nile and Yang-tse-Kiang respectively issue but one-fifth part of the flood of the Amazon. The Obe and Amoor, two of the chief rivers of Russia, each pour into the ocean but one-eighth of this volume; and the great South American river discharges nine times as much water as the Ganges or Indus.

10. **Changes of Level.**—The changes in the level of rivers are *periodical* and *casual.* The periodical changes, which are daily, monthly, semi-annual, and annual in their character, are caused by the tide, by the melting of snow and ice, and by the recurrence of heavy rains at stated seasons. The influence of the tide is exerted daily and monthly,—the high and low tides occurring twice a day, and the spring and neap tides twice a month. The lower portions of streams which enter the ocean will consequently have their levels affected by this cause, the extent of this influence being modified by the breadth and shape of their channels and the force of their currents. In the Amazon the tide extends more than 576 miles up the stream; in the Thames, 70 miles; and in the Columbia, 100 miles.

Where rivers descend from mountains that tower above the limit

What are cañons? Describe them. Where do they abound? What river has the finest? Describe the channel of the Colorado. Describe the Black and Big Cañons. 9. Upon what does the size of a river depend? Describe the large rivers of the globe in order. 10. What is the nature of the changes in the level of a river? State the causes of periodical changes. Show the effect of the tide. Give instances.

of perpetual frost, a daily rise takes place in the upper part of the stream, from the melting of the snow,—the increase being greatest during the hottest days. Such is the case with many rivers among the Himalayas and in some parts of Africa. In Peru and Chili there are small rivers which run only in the day, being caused solely by the melting of the snows.

In countries within and near the tropics, where the year is divided into two seasons, the rainy and the dry, rivers are subject to semi-annual and annual changes of level, which arise from two distinct causes,—the melting of the snow in spring and summer, and the fall of rain during the wet season. The rivers which are affected by both these causes have semi-annual floods; and those which are influenced only by the latter, annual inundations. The Tigris rises twice a year,—first in April, on account of the melting of the snow in the Armenian mountains, and secondly in November, when a smaller rise is caused by the periodical rains.

The Mississippi also rises semi-annually. The first and smaller flood occurs in January, and is caused by the periodical rains. Its chief rise takes place in March and continues till June, and results from the melting of the snows in the upper part of its basin. The great river then swells in some places to the height of forty or fifty feet above its ordinary level, expanding into broad lagoons and bayous from thirty to one hundred miles wide.

But the greatest river-floods are annual; and the mightiest of these occur in the vast plains of South America. There the Orinoco, rising from the close of March to the last of August, floods the surrounding plains to the depth of from twelve to fourteen feet, over an area six hundred miles long and from sixty to ninety miles wide, the inundation in some instances swelling fifty feet above the usual level. The Amazon being in the southern tropic, while the Orinoco is in the northern, the dry and wet seasons are interchanged, and the rise of the former, beginning in December, is greatest in March, and least in July and August.

The Ganges, Indus, Niger, and Gambia are likewise subject to annual inundations of great extent, dependent upon the stated rains.

But the most remarkable of all annual floods is that of the Nile, which has recurred with the utmost regularity for thousands of years, dating back to the very dawn of history. It results from the periodical rains which fall in torrents upon the rugged plateaus of Abyssinia and descend by numerous streams into the bed of the great river. The inundation of the Nile begins near the middle of June, and continues to increase until the middle of September. It then remains stationary for a few days, when it begins to subside, diminishing till about the middle of December.

OVERFLOW OF THE NILE—SUEZ RAILROAD.

To the swell of the Nile Egypt owes its extraordinary fertility, the river spreading over its plains the enriching sediment brought down from the mountains. On this account, Egypt has been appropriately termed the "Gift of the Nile."

The casual variations in the level of rivers arise from occasional strong winds and heavy rains. Thus, a strong easterly wind causes a rise in the waters of the St. Lawrence. A violent easterly wind checks the current of the Orinoco to such an extent that, in the upper part of its course, the waters are forced back into the tributary streams, reversing their currents and causing inundations. The Baltic is likewise driven up the Oder, and swells its stream to a considerable distance, under the pressure of a northerly wind.

CLASSIFICATION OF RIVERS.

11. The rivers of the globe are divided into two classes,—*Oceanic* and *Continental.*

OCEANIC RIVERS.

12. Under this class are comprised all the rivers which empty, directly or indirectly, into the sea. It is further subdivided into *four systems,*—namely, the *Arctic, Pacific, Atlantic,* and *Indian Systems,* each being designated by the name of the ocean into which its rivers flow.

13. **Arctic System.**—This division embraces all the rivers that flow into the Arctic Ocean from the northern slope of the Eastern and Western Hemispheres. The chief streams in the Eastern Hemisphere are the Obe, Yenisei, and Lena.

The Obe springs from the Altyn Kool, or Golden Lake, in Siberia, and flows with a sluggish current for the distance of 2500 miles, draining about one-sixth of Siberia, its basin having an area of 924,800 square miles.

The Yenisei winds along for nearly 2300 miles, receiving many tributary streams, which in their middle and upper courses are impetuous torrents. The basin of this noble river is 784,000 square miles in extent.

The Lena, which is the smallest of the three, is 2600 miles long, and drains a basin containing 594,000 square miles. It rises in the mountain-ranges near Lake Baikal, and, after receiving various affluents, enters the ocean through many mouths, descending slowly between banks of frozen mud and sand, in which are imbedded the remains of extinct species of elephants and rhinoceroses.

In the Western Continent, few streams flow into the Arctic Ocean. The principal are the Mackenzie, Coppermine, and Great Fish Rivers. Of these the Mackenzie is the largest. It rises on the eastern declivity of the Rocky Mountains, and, flowing for 2600 miles, drains an area of 441,600 square miles. The rivers of this system, though large, are of but little importance except for drainage. Being frozen in their lower course for half the year, or more, they are unfit for navigation; and when the melting of the snows at their more southerly sources sends down an increased flood, their

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What is said of the swelling of rivers which flow from ice-capped mountains? What is stated respecting their changes of level in countries within or near the tropics? Give the illustrations. How often do the greatest river-floods occur? Describe those mentioned. How are casual variations in the level of rivers caused? Give the instances mentioned. 11. How are rivers classified? 12. What are oceanic rivers? How many river-systems are there, and how designated? 13. Describe the chief rivers of the Arctic system. Are they of much importance?

ice-locked mouths check the swelling waters, and cause inundations over the neighboring plains, transforming them into dreary morasses and desolate tundras.

14. **Pacific System.**—The river-system of this mighty ocean is altogether disproportionate to its own extent. In the Western Hemisphere the vast mountain-ranges that stretch from the Arctic Ocean to Cape Horn run so near to the Pacific that but few rivers of any size enter its waters from this region.

The only rivers of any note are the Colorado and the Columbia. The former, with its wondrous cañons, has already, for the most part, been described. It remains to be added that it is about 1100 miles long, and drains an area of 170,000 square miles.

The Columbia rises in the Rocky Mountains, and, after an impetuous course, in which it rushes in cataracts and rapids between walls of trap rock 1000 feet high, enters the Pacific below Astoria. This river is 1200 miles long, drains an extent of 194,000 square miles, and is navigable for small vessels 100 miles from its mouth.

From Eastern Asia many large rivers fall into the Pacific, since the great mountain-ranges are there situated farther inland than in America. Chief among these are the Amoor, Hoang-Ho, Yang-tse-Kiang, and Cambodia.

The Amoor, termed the "Great River of the Black Dragon," rises in the Daurian Mountains, in Eastern Siberia, and, after a course of 2200 miles, enters at the junction of the Seas of Japan and Ochotsk. Its basin is 582,880 square miles in extent, and is a productive region. This river was explored by "an American, Mr. P. M. Collins, about ten years ago; and it will doubtless prove to be of great commercial importance in developing trade between Eastern Russia and Western America."

The Hoang-Ho and Yang-tse-Kiang are the great rivers of China. They rise in the mountains that flank the table-land of Tartary, and, traversing the Chinese plain, enter the Yellow Sea only ninety miles apart. The length of the former is 2500 miles, and the extent of its basin 537,400 square miles: the latter is 3000 miles long, and drains an area of 547,800 square miles. They are both navigable for vessels of considerable size for 600 to 800 miles from their outlets, and for small craft to twice these distances.

The Cambodia is a noble stream, 2000 miles long, with a basin 216,000 square miles in extent. It rises probably near the sources of the Yang-tse-Kiang, and, after watering Cochin China and Cambodia, enters the Chinese Sea.

15. **Atlantic System.**—Into the Atlantic pour, either directly or indirectly, not only the mightiest rivers of the globe, but the largest number of its noblest streams. Europe contributes all her oceanic rivers except the Dwina; Africa sends down her northern and western floods; while from the vast eastern slope of the New World, from the Arctic circle to Cape Horn, descend ten thousand streams to mingle with its waves.

Chief among the rivers of this system are the Danube, in Europe, the Nile, Niger, Senegal, and Gambia, in Africa, and the Saskatchawan, St. Lawrence, Mississippi, Orinoco, Amazon, and La Plata, in America.

The Danube, winding from its source in the Black Forest a distance of 1600 miles, enters the Black Sea, after draining a region 234,080 square miles in extent. The famous Nile has its sources in the Victoria and Albert Nyanza Lakes; and, after flowing about 3600 miles, enters the Mediterranean, through the two principal mouths of its delta, at Rosetta and Damietta. Its main tributaries are the Blue Nile, the White Nile, and the Tacazze. From its junction with the latter to its mouth, a distance of 1200 miles, it receives not a single affluent. The basin of the Nile has an area of 520,200 square miles.

The Niger, descending from the northern slopes of the Kong Mountains, flows for 2600 miles in a winding course to the Gulf of Guinea, entering the Atlantic through a pestilential delta 32,000 square miles in extent. The stream, spreading over its low banks, is from one to six miles wide, and is navigable in its mid-channel for several hundred miles from its mouth. In the Kong Mountains rise also the Senegal and Gambia, which are said to flow the respective distances of 700 and 1200 miles. But little, however, is known respecting them.

The Saskatchawan springs from two streams in the Rocky Mountains, which join at the distance of 450 miles from their sources; thence, flowing 200 miles, it enters Lake Winnipeg, and is discharged into Hudson Bay through the Nelson River. The Saskatchawan, with the Nelson, is about 1600 miles long, and its basin has an area of 360,000 square miles.

The St. Lawrence, at first called the St. Louis, rises in 47° 41′ north latitude and 92° west longitude, and enters Lake Superior at its southwestern extremity. Bearing off the surplus waters of the great northern lakes, it issues from Ontario at Kingston, where it receives the name of the St. Lawrence. The majestic river, now flowing amid the enchanting scenery of the "Thousand Isles," either plunges along in rapids, or spreads out in broad lakes, till it reaches Montreal. With an average width of two miles, it flows beyond this city to Quebec, and thence onward to the ocean, entering the Gulf of St. Lawrence by an outlet more than 100 miles broad.

The length of the St. Lawrence is 2200 miles. Its basin has an area of 297,600 square miles, one-third of which consists of the great northern lakes. The two most noted tributaries of the St. Lawrence are the Ottawa and Saguenay. The Ottawa, with a width of about three-quarters of a mile, enters the St. Lawrence just above Montreal; and the Saguenay joins the St. Lawrence about 120 miles below Quebec. For the distance of seventy miles from its mouth the Saguenay flows a mile in width and a thousand feet deep, between walls of rock 1000 feet high, and, apparently, fills an immense chasm formed by a rupture in the mountains of this region. At its outlet it is 700 feet deeper than the St. Lawrence, and in some places is nearly a mile in depth.

SAGUENAY RIVER.

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14. What is said of the Pacific system? Describe the principal rivers of this system. 15. What is said of the Atlantic system? Describe its prominent rivers.

LAKE ITASCA, THE SOURCE OF THE MISSISSIPPI.

Rising in Lake Itasca, the Mississippi, the longest river of the world, spreads fertility over the noble valley through which it flows, and bears upon its waters a vast internal commerce. Several large rivers swell its stream. From the Rocky Mountains, with many a daring leap, comes down the turbid Missouri, its noblest tributary; and from the east the beautiful Ohio gathers the streams of the Alleghanies. Lower down it is joined by the Arkansas and Red Rivers,—the former rising in the Rocky Mountains and flowing for a distance of 2000 miles, while the latter has its origin in the table-land of Texas. The Mississippi is 4100 miles long, and is navigable for a distance of 2240 miles; while it drains the vast area of 982,400 square miles.

The Orinoco, in South America, rises among the mountains of Parime, and drains an area of 297,000 square miles. It is 1500 miles long, is navigable for 1000 miles from its mouth, at all seasons, and is subject to extensive floods.

South of the Orinoco the mighty Amazon, unrivalled among the rivers of the globe, pours its immense flood into the Atlantic. Far up among the Andes it has its source, in the river Apurimac, and, after receiving numerous tributaries, more than twenty of which are large and important rivers, enters the ocean by an estuary 200 miles long and 135 broad. It drains an area of 1,512,000 square miles, and discharges such a vast flood into the sea that it freshens the waters of the latter hundreds of miles from the land. This great river is 3600 miles long, is from one to two miles wide at its upper sources, and is navigable for a distance of 2000 miles. Many of its tributaries admit of navigation to a great extent. The Amazon, on account of its immense facilities for internal communication, is destined at no distant period to open up to commerce and civilization the vast region through which it flows,—a region unsurpassed by any other country in natural wealth.

The La Plata rises in Brazil, under the name of the Rio Grande, and receives many tributaries in its course, the principal of which are the Paraguay and Parana, which are navigable for hundreds of miles. The La Plata waters a region 886,400 square miles in extent, and, after a course of 2250 miles, enters the ocean below Buenos Ayres by an estuary 180 miles long and 120 broad.

16. **The Indian System.**—The eastern coast of Africa, the southern of Asia, and the western of Australia discharge their streams into the Indian Ocean. The rivers of this system are not numerous; though several are of large size and famous for the historic memories that cluster around them. Among the most important are the Zambezi, in Africa, and the Euphrates, Tigris, Indus, Ganges, Brahmaputra, Irrawaddy, Meinam, and Cambodia, in Asia.

The Zambezi is a magnificent river of South Africa, and appears, from the explorations lately made by Dr. Livingstone, to be connected with several large rivers and numerous affluents. It is said, with the exception of one small rapid 300 miles from its mouth, to be navigable for 600 miles, and to drain an area of 432,000 square miles.

The Tigris and Euphrates, forming a single river-system, rise in the mountains of Armenia and Kurdistan, and, piercing the range of the Taurus, wind through the plains of Mesopotamia to the Persian Gulf. The Euphrates is 1400 miles long, and the united rivers drain an area of 195,632 square miles. No other region is so rich in historic associations as that which is watered by these famous streams. Here rose and fell the ancient monarchies of Assyria and Babylon, succeeded by the splendid empire of the Medes and Persians, which in turn yielded to the conquering arm of Alexander; and in later ages the glories of Bagdad, beneath the sway of the Caliphs, added splendor to the triumphs of the Moslems.

The Indus has its origin in the table-land of Thibet, and, after plunging down the Western Himalayas, reaches the plain of India, where it is swelled by the Punjaub (or five rivers), which spring, like the main stream, from the snows of the Himalayas. After this accession it receives no more tributaries of importance, but, flowing onward to the sea, enters it by a delta 115 miles long and 105 broad. The Indus is 1700 miles in length, and drains an area of 312,000 square miles. It is navigable only for vessels of small burden.

SCENE ON THE GANGES.

The Ganges and Brahmaputra, the sacred rivers of the Hindoos, form a double river-system, and together water an area of 432,480 square miles. The Ganges bursts from the glaciers of the Himalayas, and descends swiftly into the plain. Here it gathers in nearly twenty large tributaries, and, flowing southeasterly through the rich alluvial regions of India, enters the Bay of Bengal, after a course of 1600 miles, through a wide and mazy delta.

The Brahmaputra has its source near that of the Ganges, but on the opposite side of the Himalaya range. At first it runs easterly, but at length turns suddenly to the southwest, and, severing this mighty chain, flows onward, larger than the Ganges, and enters the delta of the latter forty miles from the sea, after running a course of 1500 miles.

The annual floods of these rivers overspread and enrich the lowlands of India for hundreds of square miles, and discharge such a volume of water into the Bay of Bengal that nearly all its upper

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16. Describe the chief rivers of the Indian system.

area is freshened by it. The Brahmaputra, from the swiftness of its current, admits of but little navigation; while the Ganges is always navigable, and light vessels can ascend it even to the very foot of the Himalayas.

The Irrawaddy, which waters the Birmese Empire, is a splendid river, and has its source amid the vast mountain-ranges that give rise to the eastern tributaries of the Brahmaputra. At Ava, 450 miles from its mouth, it is a broad and rapid stream, in some places four miles wide. Thence flowing southward with a turbid current, it forms an extensive delta at its mouth, and discharges its water into the Bay of Bengal by fourteen branches. The Irrawaddy is 1700 miles long, and drains an area of 331,200 square miles.

The Meinam and Cambodia are but little known. The former rises in the southern part of China, and, traversing the kingdom of Siam, enters the Gulf of Siam by several streams. The latter has probably its sources near the Yang-tse-Kiang, and, after flowing southward 2000 miles, between the mountain-ranges of Cochin China, enters the Chinese Sea by a broad delta 300 miles from its mouth. The united basins of the Meinam and Cambodia are 216,000 square miles in extent.

In Australia, the only river of any size which enters the ocean is the Murray, which drains Southeastern Australia.

Continental System.

17. A *continental river-system* is one where the streams either run inland towards a depressed basin which has no connection with the ocean, or, flowing seaward, are swallowed up by intervening deserts, never reaching the coast.

The principal depressed areas are the Caspian and Aral, Dead Sea, Utah, and Titicaca basins; and probably similar depressions exist in Northern Africa and Australia.

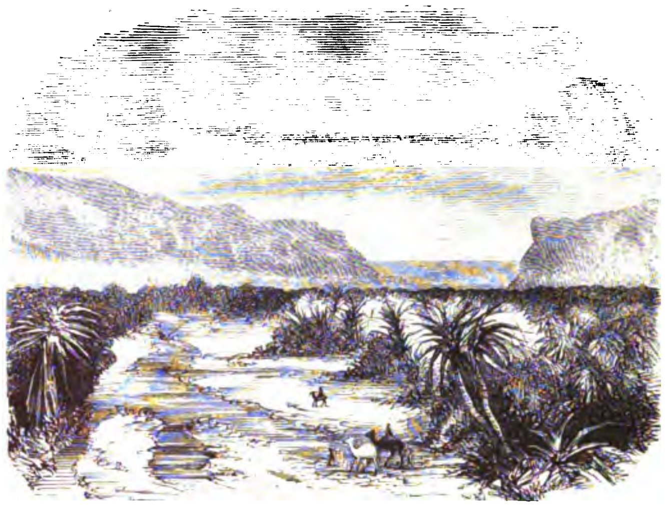
The Caspian and Aral system is the largest of this class. Into these seas numerous rivers enter, the chief of which are the Volga, Ural, Sihon, and Amoo. The Volga, which is 2000 miles long and waters a region 397,460 square miles in extent, enters the Caspian by seventy mouths. The Sihon and Amoo flow into the Aral, their united basins being 431,920 square miles in extent. This system includes also the minor basins of Central Asia, comprising the lakes Balkash, Lop, and others, whose affluents drain an area of 177,000 square miles.

The Dead Sea receives several streams: the most noted is the Jordan, which rises in Syria, at the base of the Anti-Lebanon ranges.

In the basin of Utah are several rivers, of which the Humboldt is the finest; and all of them flow into the lakes of this table-land. From both the ranges of the Andes many streams enter Lake Titicaca, in Bolivia; but its only outlet is the river Desaguadero, which is lost by evaporation and by absorption in the sandy wastes into which it runs.

The central highlands of Arabia, which are described by a late traveller (Palgrave) as a most delightful and fertile region, are abundantly watered by springs and streams. But none of the torrents that channel the hills find their way to the sea, being either absorbed by the light soil of the valleys, or drunk up by the sands of the deserts which girdle the fruitful central hills,—sands so deep and extensive that a Euphrates might be lost within them.

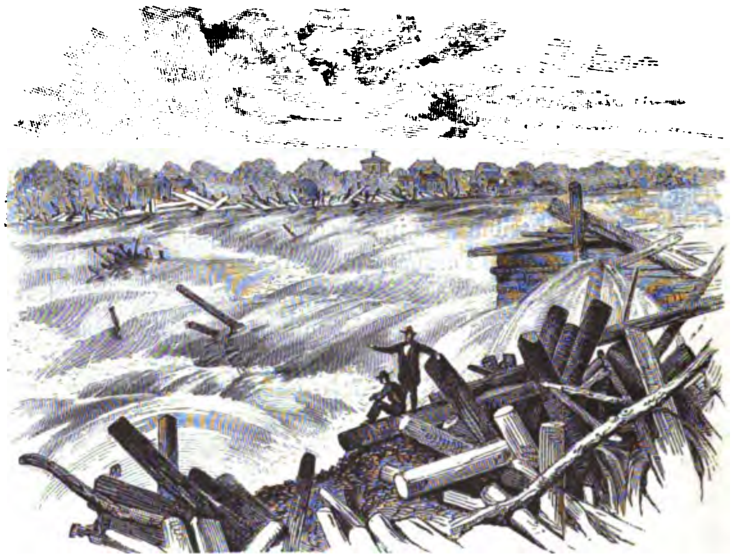
The interior of Australia has been but little explored; but the knowledge obtained seems to warrant the conclusion that it constitutes a large continental basin, having marshes, salt lakes, and a system of internal drainage.



STREAM IN THE DESERT.

18. **Importance of Rivers.**—Rivers are the great natural highways through which commerce reaches the heart of a continent. The finest streams flow through the most fertile tracts; for the very processes by which rivers have been formed have given birth to the rich alluvial plains that border their banks; and transportation is thus provided for the excess of production that springs from these fruitful regions.

In the winding channels of rivers a most beneficent arrangement is perceived; for they are thus enabled to water a larger area, and afford more points of access for internal commerce, than if they swept in a straight course to the sea. Checked by their curving banks, and having but little descent in their lower courses, the noblest streams of the globe possess a slow motion and a great depth. Large vessels can therefore easily ascend their waters, and populous and prosperous cities grow up in the interior, nourished by the life-blood of commerce which flows through these great arteries of the globe.



ST. ANTHONY'S FALLS, AT HIGH WATER.

What is said of Australia in respect to ocean-rivers? 17. What is a continental river-system? Describe the most prominent systems. What is said of the interior of Australia? 18. What is said of the importance of rivers? What beneficent arrangement is perceived in their winding channels?

OCEANIC SYSTEM.

CHAPTER IV.

THE OCEAN.

1. The *Ocean*, with its grand movements as displayed in *Waves*, *Tides*, and *Currents*, constitutes the second division of the waters of the globe, termed the *Oceanic System*.

THE OCEAN.

2. **The Ocean.**—The ocean is that unbroken expanse of water which encircles the continents and islands and forms the counterpart of the land. Its great divisions, as the Atlantic and Pacific, correspond to the continents; its seas and gulfs, to the peninsulas; its lesser bays, to capes; and its shoals, to isthmuses. The lake, also, is but a watery island.

In the relief of the ocean the same law obtains, its varying depths answering to the different heights of the land; for its floor consists of submarine plains, table-lands, and mountain-ranges whose towering summits, emerging from the waves, break the monotony of the sea-level by groups and chains of islands. Marine rivers and streams traverse its depths in all directions with a continuous flow, and the waters of the main are as full of animal life as the verdant earth; groves and grottos of coral mimic those of the land, and sea-flowers of the richest hues bloom beneath the waves.

3. **The Extent and Divisions of the Ocean.**—The ocean embraces an area of 145,500,000 square miles, or about three-fourths of the entire surface of the globe. For the sake of description, it is comprised under five great divisions, also called oceans, each of which has its own systems of seas, gulfs, and bays. These divisions are the Arctic, Atlantic, Indian, Pacific, and Antarctic Oceans.

The Arctic Ocean is bounded on the south by the Arctic circle, and contains about 4,000,000 square miles. Many daring navigators have sought to reach through its waters the northern pole; but the vast ice-fields that cover its surface have thus far frustrated every attempt. On the 22d of June, 1827, Captain Parry, leaving his vessel in harbor, succeeded, by travelling for a month over the ice, in reaching the high northern latitude of 82° 40′; but at this point the ice-fields drifted southward faster than the explorer could advance northward.

On the 24th of June, 1854, a portion of the exploring party under Dr. Kane reached the parallel of 82° 30′ north latitude, and on May 19, 1861, Dr. Hayes penetrated as far as 81° 35′ north latitude.

This ocean near its southern limits is by no means open, for immense masses of ice float in its waters, many of which, drifting southward, melt away in the warmer waters of the Atlantic. The floating ice consists principally of two kinds, *ice-fields* and *icebergs*. The former, which consist of frozen salt water, are often of immense extent, sometimes having an area of 100 square miles. The latter are of fresh-water origin, and are formed on land.

In Greenland the shores of the ocean are skirted by ice-cliffs for a distance of 600 miles, caused by the freezing of the water which flows towards the sea in summer from the melting snows in the interior. The masses of ice thus formed, gradually increasing, at length overhang the sea, and are undermined by its waves. Immense portions of ice at last give way, and, falling into the sea, become icebergs.

The branches of the Arctic Ocean are Baffin Bay, the White Sea, Sea of Kara, and Behring Strait.

The Atlantic Ocean.—The Atlantic Ocean, divided by the equator into the North and South Atlantic, extends from the Arctic to the Antarctic circles, and is bounded by America on the west and Europe and Africa on the east. It is 9000 miles long, varies in breadth from 900 to 4000 miles, and covers an area of about 25,000,000 square miles.

This ocean, lying between regions inhabited by the most civilized and enterprising nations of the earth, is the great highway of the commerce of the world, and thousands of vessels constantly traverse its waters; while its numerous inlets give access to the most productive regions, piercing deeply into the continents, and thus affording remarkable facilities for traffic.

Its chief branches are the Baltic, German Ocean, Mediterranean, Gulf of Guinea, and Black Sea, on the east; and the Gulf of Mexico, Caribbean Sea, and Hudson Bay, on the west.

The Indian Ocean.—This ocean is bounded north by Asia and south by the Antarctic circle, and extends from Africa on the west to Australia on the east. It is more than 4000 miles wide, and has an area of about 23,000,000 square miles. Its principal branches are the Arabian Sea, the Persian Gulf, and the Bay of Bengal. The last is the most important branch, being the avenue of modern commerce to the wealth of India.

The Pacific Ocean.—The Pacific Ocean is bounded on the east by North and South America, west by Asia, the Sunda Isles, and Australia, north by Asia and America, and south by the Antarctic circle,—being divided by the equator into the North and South Pacific. Its principal branches on the west are the Ochotsk, Japanese, Yellow, and Chinese Seas; and on the east, the Gulfs of California and Panama. It is distinguished for its vast size, comprising nearly two-thirds of the surface of the entire ocean, and is also noted for its numerous islands, to which the name of Oceanica has been given.

The Pacific was unknown to the civilized world until about 350 years ago, when Vasco Nuñez de Balboa, having crossed the Isthmus of Darien, beheld, on the 13th of September, 1513, from a lofty mountain, the waves of this mighty ocean rolling before him. Seven years later, Fernando Magellan, seeking a westward passage to the Maldive Isles, entered this ocean through the strait that bears his name. From the tranquillity of its waters he gave it the name of

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1. What does the Oceanic System include? 2. Describe the ocean. 3. What is said of the extent and divisions of the ocean? Name these divisions. Describe the Arctic Ocean. How far northward have explorers penetrated? What is the nature of the ice? What are icebergs? Describe the Atlantic Ocean. Describe the Indian and Pacific Oceans. State what is said of the discovery of the Pacific Ocean.

the Pacific: it is, however, vexed by storms, yet not to such an extent as the Atlantic and Indian Oceans. It is now the seat of a large portion of the traffic of the world, and its commercial importance will rapidly increase when railroads unite at different points the Pacific and Atlantic, as will soon be the case, thus greatly lessening the time of transit between Asia and Europe.

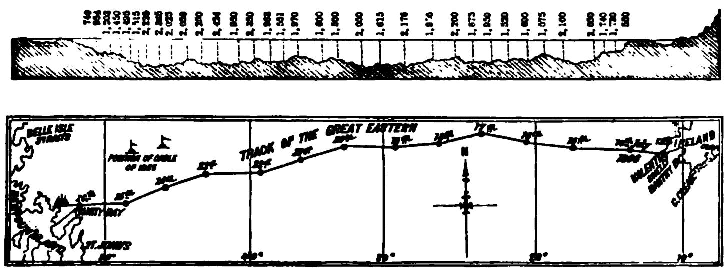
Antarctic Ocean.—This ocean is bounded north by the Antarctic circle, and extends to the southern pole. It has the same character as the Arctic Ocean, but is more effectually ice-locked. In the year 1841, Sir James Ross passed through a field of floating ice 800 miles broad, to as far as 78° 10′ south latitude, the highest point yet attained.

The icebergs of this ocean are of different shape from those of the Arctic, having a tabular form. They drift down in immense numbers to lower latitudes than those of the northern seas, some having been met with at the Cape of Good Hope and at the mouth of the La Plata, in 36° south latitude. An Antarctic iceberg was observed by Captain Dumont d'Urville, which was 13 miles long, with perpendicular sides 100 feet high. Its depth below the surface of the sea must, therefore, have been about 800 feet.

4. **The Bed of the Ocean.**—The investigations of science lead to the conclusion that the shape of the ocean-bed resembles that of the land, being diversified with deep valleys, gentle slopes, broad table-lands, and lofty mountains. It appears to be more rugged than the land; and this difference is probably owing to the action of the winds, rivers, rains, and frost, which wear away the eminences and fill up the depressions on the land, while the bed of the sea is subject to but little disturbance.

Great praise is due to the American navy, who, by their improved mode of taking deep-sea soundings, have much increased our knowledge in respect to the ocean-bed. The basin of the Atlantic, which has been best explored, is found to be a deep valley, rising by a succession of irregular table-lands to the shores of the Eastern and Western Continents. From the researches of the Coast Survey between New Jersey and Block Island, it appears that the bottom of the ocean descends about five feet in a mile to the distance of 100 miles from the shore, being at this point 500 feet deep, but beyond this limit it descends 400 feet in a mile.

The boundary-line of the first submarine plain, 6000 feet below the surface of the sea, is about 120 geographical miles from the present coast; and that of the second terrace, 6000 feet lower, is reached at the distance of 250 geographical miles.



THE ATLANTIC CABLE.

Telegraphic Plateau.—From the explorations made by Captain Berryman, of the United States steamer Arctic, it appears that between Ireland and Newfoundland the bed of the Atlantic forms a level expanse, about 400 miles broad, and in no place exceeding 13,000 feet in depth, covered with the broken shells of minute marine animals. This is termed the *Telegraphic Plateau;* for on this bed now rest those wondrous cables which unite the Eastern and Western Hemispheres. After several failures, telegraphic communication was successfully established on the 27th of July, 1866.

5. **Depth of the Ocean.**—The ocean has been sounded by various navigators. Nine hundred miles west from St. Helena, Sir James Ross found no bottom with a line 27,600 feet long. Lieutenant Walsh, on the 15th of November, 1849, when in 31° 59′ north latitude and 58° 43′ west longitude, found no bottom with a line of 34,000 feet; and in the South Atlantic, no bottom was reached by Captain Denham and Lieutenant Parker, in the same region, when the former sounded with a line of 46,000 and the latter with one of 50,000 feet. These results, however, are not considered as strictly accurate, as sufficient allowance was not made for the effect of submarine currents carrying out the line sideways, and also for other sources of error.

The greatest depth reached by the improved methods of sounding is 25,000 feet, and occurs in the North Atlantic. The average depth of the Pacific in a line from Simoda, in Japan, to San Francisco, California, a distance of 4500 miles, has been estimated by Professor Bache, from the theory of waves, to be 14,190 feet. From calculations on the velocity of tidal waves, it has, however, been estimated that the extreme depths of this ocean are about 50,000 feet, or more than nine miles.

6. **Saltness.**—The waters of the entire ocean are salt: 1000 ounces of this water consists of 964 ounces of pure water, 27 of common salt, and the remainder of various substances, such as lime, silica, sodium, potassium, bromine, and other substances. Lime and silica are of great importance to marine life, as they furnish materials for the shells of mollusks and for the structures of the coral insects.

Inland seas with a narrow channel are usually less salt than the main ocean. The Baltic Sea, which drains one-fifth of Europe, is but about half as salt as the German Ocean; and a similar difference is observed between the Black Sea and the Sea of Azof. The Mediterranean, however, is an exception,—its waters being four times salter than the Atlantic: this result is supposed to be caused by the excessive evaporation which occurs in this sea and carries off a much larger quantity of fresh water than flows into it, while a current of salt water is continually setting in from the Atlantic.

The ocean near the tropics is salter than in the vicinity of the equator, and its freshest waters are in the polar seas. The difference is due to the vast amount of rain that falls near the equator, and to the melting of the polar ice and snow. The saltness of the sea is greatest at the parallels 18° north and south latitude.

The sea is freshened at the surface to a considerable distance from outlets of large rivers. At the mouth of the Amazon, fresh water may be taken from the surface of the sea out of sight of land, and at the distance of three hundred miles from the shore the water is only brackish. During the inundation of the Nile the saltness of the Mediterranean is lessened at a great distance from the shore.

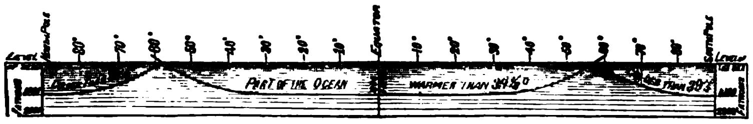
The cause of the saltness of the sea is unknown. Vast deposits of rock-salt constitute a portion of the globe; and with these its waters may possibly come in contact. Moreover, for ages the rains have constantly returned in rivers to the sea, charged with the

Describe the Antarctic Ocean. What is said of the icebergs of this ocean? 4. What is the nature of the bed of the ocean? Describe the basin of the Atlantic. What is meant by the Telegraphic Plateau? 5. State what is said respecting the depth of the ocean. What is the greatest known depth? What is the average depth of the Pacific, according to Professor Bache? 6. What is said of the nature of sea-water? Are the waters of the ocean equally salt in every part? State what is said on this point. Do we know the cause of the saltness of the sea?

various saline ingredients which have been dissolved in them; while nothing but the purest water is returned by evaporation to the land, the foreign matter being left in the ocean.

7. **Density.**—Sea-water, impregnated as it is with salt and various other substances, is heavier than fresh water. A cubic foot of the latter weighs 1000 ounces; while the same bulk of the former has an average weight of about 1028 ounces. It is, therefore, more buoyant than fresh water, and better adapted to navigation. Moreover, freezing at the temperature of 28½° Fah. instead of 32° Fah., as is the case with fresh water, the ocean is less ice-locked than it would be if it consisted of the latter.

8. **Temperature.**—The temperature of the ocean changes with the depth, until at length the constant temperature of 39° Fah. is reached,—showing the extent of the sun's influence. This point of unvarying temperature is found, at the equator, at the depth of 7200 feet, where the temperature at the surface is about 80° Fah. To the south of the equator the waters become gradually colder, until they reach at the surface the temperature of 39° Fah. in 56° 26′ south latitude. Here the temperature of the ocean is the same at all depths. From this parallel to the southern pole the deep sea is warmer than the surface, and the point of constant temperature of 39° Fah. again sinks beneath the waves, attaining the depth of 4200 feet in 70° south latitude, while the waters of the surface have the temperature of 30° Fah. The same law is said to prevail in the northern hemisphere. Thus the ocean is divided into three great zones,—an equatorial and two polar zones,—the warmer water being at the surface in the former, and the colder in the two latter.



LINE OF CONSTANT TEMPERATURE OF THE OCEAN.

Oceanic Equator.—The line of greatest warmth, or the oceanic equator, does not coincide with the geographical equator, but is deflected by the influence of currents and the proximity of land intensely heated. In the Atlantic the line of greatest heat is entirely north of the equator, its highest temperature of 89° Fah. being found in north latitude 28°. In the Indian Ocean the highest temperature is 87° Fah., and occurs in the Arabian Sea; that of the Pacific is near New Guinea, and is about 89° Fah.

The mean temperature of the surface of the sea at any point, when unaffected by currents, is nearly the same as that of the atmosphere above it. This temperature decreases with the increase of latitude, sinking gradually from the greatest equatorial heat of 89° Fah., towards either pole, till the sea becomes frozen and covered with fields of ice. This variation is not, however, uniform, owing to the prevalence of warm and cold currents, and the melting of the polar ice; and the change is more rapid in the southern than in the northern hemisphere.

Various Arctic explorers and men of science have believed that the temperature of the ocean decreases towards the north up to a certain limit, beyond which it increases, and that around the north pole there exists an iceless sea of a circular form, more than 2000 miles in diameter. This view is not received by others, who maintain that the vast spaces of open water called Polynjas, which are found in very high latitudes and are sometimes reached through the floating ice, are caused by the action of winds and currents. Such an open sea was beheld by Morton, under Dr. Kane, on the 24th of June, 1854, in 82° 30′ north latitude. Far as the eye could see, no ice could be descried, the waves breaking at the foot of precipices two thousand feet high. In May, 1861, Dr. Hayes stood upon the shore of this sea, which was then filled with broken ice.

It has always been a favorite object with the Arctic explorers to find a route between Europe and Asia by the northern ocean. Unparalleled dangers and hardships have been heroically encountered and endured to attain this object, and at length, after years of trial and disappointment, the Northwest Passage was discovered by Captain M'Clure, in 1856; but the difficulties that beset it are so formidable that it can never be a pathway for commerce.

9. **Color of the Ocean.**—The color of the deep ocean is a rich blue; its shallow waters have a greenish hue; but its tint varies with the fitful changes of the sky, as the latter is darkened by clouds or glow in sunshine.

Certain parts of the ocean, from the admixture of foreign matter, assume different hues. The Red Sea contains a red coloring-matter, which was found by Ehrenberg to be of vegetable origin. In the Indian and Pacific Oceans, long tracts of red, white, and brown water are frequently seen, which are alive with animalcules having the same hue as the water.

Nearly one-fourth of the Greenland Sea, comprising an area of 20,000 square miles, is of a deep olive hue, caused by the presence of minute marine animals; and a similar phenomenon, arising from the same cause, was seen by Dr. Poeppig near Cape Pilares,—the vessel, as it advanced, throwing up bright purple waves from its bows, which changed into rose-tinted water in the track of her keel.

10. **Phosphorescence.**—During the darkness of the night the sea is not unfrequently beheld glowing with a phosphorescent light: with every movement its waters burst into brightness, and the refulgent waves appear like billows of fire. This phenomenon is one of great beauty and magnificence, which, though confined to no particular part of the ocean, attains its greatest splendor in the tropical climes.

"While sailing," says Darwin, "a little south of the river La Plata, on one very dark night, the sea presented a wonderful and most beautiful spectacle. The vessel drove before her bows two billows of liquid phosphorus, and in her wake she was followed by a milky train. As far as the eye could reach, the crest of every wave was bright, the reflected light of which illumined the horizon."

The same phenomenon is thus described by Colton:—"We had last night a splendid exhibition of aquatic fireworks. The night was perfectly dark, and a thousand living rockets were seen shooting from the ship in all directions, and whirling about in flame-like paths, till the whole ocean seemed medallioned with fire. The light was so strong that we could see the fish darting about, with great distinctness; and the track of the ship was visible for half a mile." This brilliant phenomenon is caused by marine animals, which have the power of emitting light, like the glow-worm or the fire-fly.

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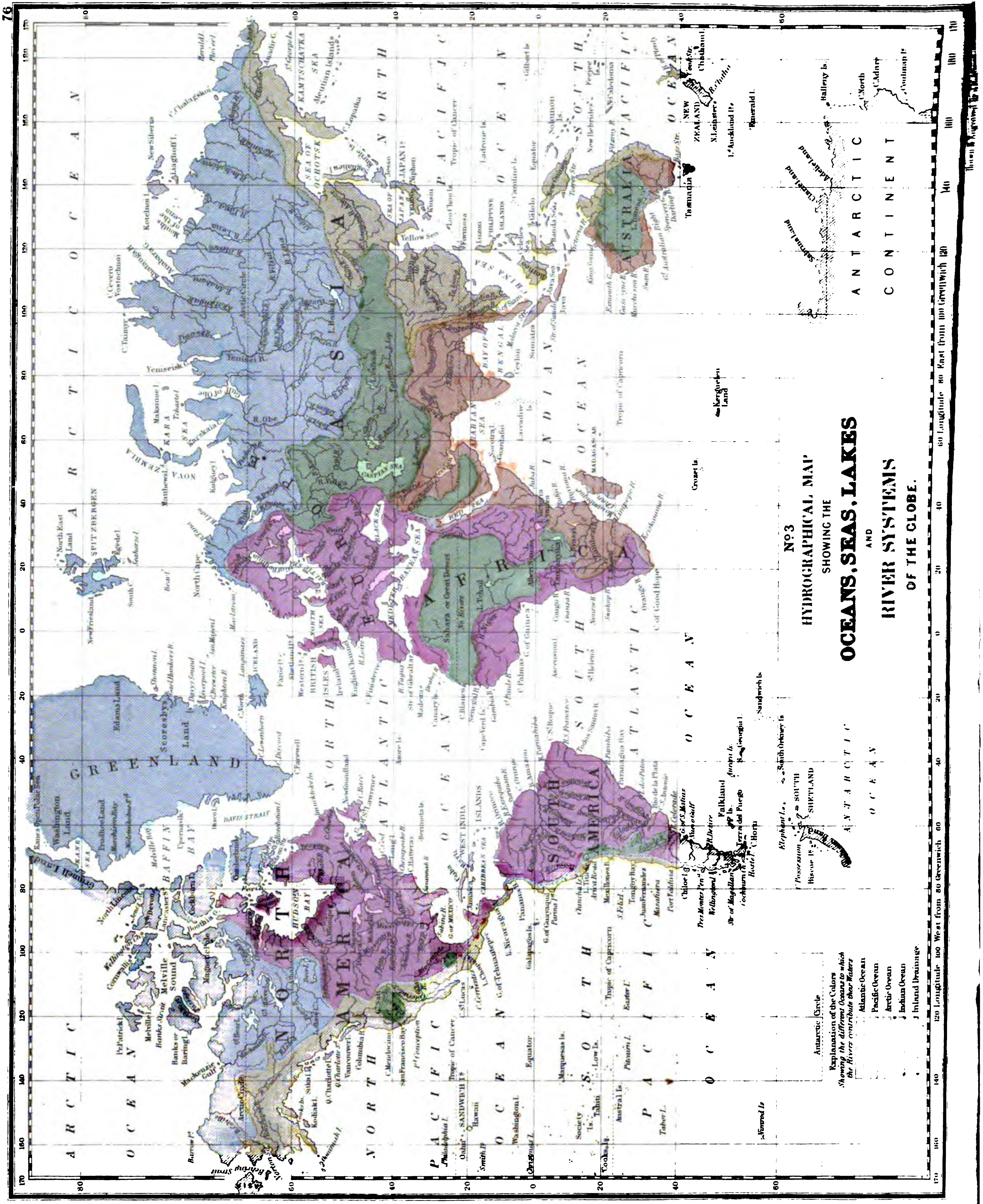
7. What is said of the density of sea-water? 8. What is said of the temperature of the ocean in relation to its depth? State what is said in regard to the point of invariable temperature. Into how many zones of temperature is the ocean divided? What is the oceanic equator? State what is said of the highest temperatures of the different oceans. What is said respecting the surface-temperature of the ocean? What are the views of scientific men in regard to an open sea around the north pole? Give the facts stated. What is said respecting the Northwest Passage? 9. What is the color of the ocean? Are different hues found in certain parts of the same? How do they arise? 10. State what is said of the phosphorescence of the sea. Give the instances cited. How is it caused?



No 3
HYDROGRAPHICAL MAP
SHOWING THE
OCEANS, SEAS, LAKES
AND
RIVER SYSTEMS
OF THE GLOBE.

Explanation of the Colors
Showing the different Oceans to which the Rivers contribute their Waters

- Atlantic Ocean
- Pacific Ocean
- Arctic Ocean
- Indian Ocean
- Inland Drainage

REVIEW AND MAP QUESTIONS ON SPRINGS, LAKES, RIVERS, AND OCEANS.

What is the subject of Part Fourth?
Into what three principal systems are the waters of the globe divided?
What are the subdivisions of the Land System?

SPRINGS.

What are natural springs? Dropping springs? Thermal springs? Mineral springs?
Name the different mineral springs.
What is said of petroleum springs?

LAKES.

What is a lake?
Name the great lake-systems of the globe.
Trace on the map the lake-systems of Europe and Asia, and describe their chief lakes.
Point out the lake-system of Africa, and describe it.
Where are the lake-systems of the Western Continent situated?
Describe them.
What is said of the lakes of Eastern South America and Australia?
Give the classification of lakes, with examples from the text and map.
What is the origin of salt lakes?
What is said of the transparency and depth of lakes, and of their uses?

RIVERS.

What are rivers?
What are the principal characteristics of rivers?
What is said of the source of rivers? Their basins? Water-sheds? Courses? Deltas? Velocity?
What are some of the most remarkable falls?
What is said of the magnitude of rivers?
What of the changes of level in rivers?
Give the illustrations.
Into what two classes are rivers divided?
Define oceanic rivers.
What are the four systems of oceanic rivers?
Describe these systems, and trace out on the map the principal rivers belonging to each.
What are continental rivers?
What are the chief continental systems?
What is said of the importance of rivers?

OCEANS.

What is the oceanic system?
Describe the ocean.
What are the divisions of the ocean?
Point out on the map the Arctic, Atlantic, Indian, Pacific, and Antarctic Oceans, and their several branches.
What is said of the bed of the ocean?
Describe the profile of the Atlantic Ocean (see Chart of Ocean-Currents, page 85).
Describe the basin of the Atlantic (see same chart).
What is the Telegraphic Plateau?
What is said of the depth of the ocean?
What of its saltness? Why is it salt?
State what is said of the temperature of the ocean in respect to depth.
What of the temperature of its surface?
Give from the map the temperature of the Atlantic Ocean, and state near what places or in what latitudes and longitudes the several temperatures occur (see Map of the Temperature of the Ocean, page 80).
Of the Indian Ocean.
Of the Pacific Ocean.
What is said of the color of the ocean?
What of its phosphorescence?

CHAPTER V.

OCEANIC MOTIONS.

1. **The Ocean** is subject to three great movements,—namely, *waves*, *tides*, and *currents*. These arise from different causes,—waves being produced by the action of the wind, and occasionally by earthquakes; tides, by the attraction of the sun and moon; and currents, by the trade-winds, the rotation of the earth, the heat of the sun, and various other influences.

WAVES.

2. **Waves** are transient in their character, and are caused by the wind in the following manner: the breeze, striking obliquely upon the surface of the water, presses certain portions below its general level, while the contiguous portions rise; then the latter in their turn descend, raising the former; and thus the surface of the water becomes alternately elevated and depressed.

Waves appear to possess a progressive motion; but this is an illusion: the *form* of the wave is progressive, the water of the wave simply moves up and down,—except in the case of storms or upon a shelving shore. That the wave does not advance, is evident from the fact that a floating body, as a duck, is now seen on the crest of the billow and then in its trough.

3. **Size and Velocity of Waves.**—Waves are small at first, and vary with the strength and inclination of the wind. As they advance they increase in size under its continued pressure; and on this account the largest waves are found in the open sea, where the sweep of the gales is unbroken.

The highest waves occur off the Cape of Good Hope during a northwestern gale, when they rise to the height of forty feet above the general level of the ocean. Waves thirty-two feet high have been observed off Cape Horn; and on the route between Europe and America, Dr. Scoresby, in 1843, estimated the greatest waves of the Atlantic to have an altitude of forty-three feet. In severe storms, when waves roll highest, the billows are not single, but consist of a series of waves accumulated upon one another. The upper waves are the lightest, and, when broken by the winds, are driven forward in foam or dissipated in clouds of spray.

The breadth of a wave, its velocity, and the depth of the water in which it travels, have all been found by Professor Airy to have a relation to one another. A wave 100 feet broad and moving in water 100 feet deep has a velocity of about fifteen miles an hour; while another 10,000 feet broad and traversing the ocean at the depth of 10,000 feet advances at the rate of 154 miles an hour. It is owing to this relation that Professor Bache was enabled to compute by means of the tide-waves the depth of the Atlantic, which he found to be on an average 22,000 feet,—a result which accords very well with the soundings that have been made in this ocean.

When the billows of the sea roll towards the land, the waves in the deep water are not balanced by those in the shallows near the shore, and the water has then a progressive motion landward. As they advance, the waves striking the bottom are retarded at their bases, while the upper portions are driven forward, and, being unsupported, curl over and break, rushing in foam towards the land. Waves of this character are termed *breakers*, and where they extend through

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What is the subject of Chapter V. 1. To what great movements is the ocean subject? 2. How are waves caused? 3. What is said of the size of waves? How high do they rise? What is said respecting the relation between the breadth, depth, and velocity of waves? Give the illustration. How are breakers caused? What is surf?

a long line of shore, receive the name of *surf.* Scarcely any thing is more sublime than the majestic billows breaking and thundering for miles along the shore. Madras in India is noted for its surf: here the rolling waves break during heavy gales in nine fathoms of water and at the distance of more than four miles from land.

After a storm has subsided, the ocean continues for a while to heave and roll in billows; for the effect of the wind does not cease at once. The vast undulations of the sea are propagated in some cases to the distance of 1000 miles, far beyond the area of the tempest which caused them; and the ocean rocks in mighty waves in regions where the atmosphere is perfectly calm and serene. This motion is termed the *ground-swell.*

4. **Earthquake-Waves.**—These waves owe their origin to the upheaval or depression of the ocean-bed by volcanic action, the sea rising or falling where this commotion happens. From this spot as a centre, vast waves roll outward in all directions, higher and more terrific than those caused by the wind.

On the 23d of December, 1854, immediately after an earthquake, the sea rolled in upon the town of Simoda, in Japan, in a wave thirty feet high, overwhelming it in an instant. After the wave fell, there was only four feet of water in the harbor. Four or five similar waves followed at intervals, completing the destruction of the town.

By observation on the tide-gauges at San Diego and San Francisco, in California, which registered all the changes in the sea-level, Professor Bache discovered that these earthquake-waves had travelled across the Pacific. The distance from Simoda to San Francisco is 4527 geographical miles, which was traversed in twelve hours and twenty-eight minutes, giving a velocity of more than six miles a minute. At San Diego, which is 4917 miles from Simoda, the waves arrived about an hour later than at San Francisco, and the velocity was sensibly the same. From the data furnished by this phenomenon, Professor Bache estimated the depth of the Pacific in the path of these earthquake-waves to be about 13,000 feet.

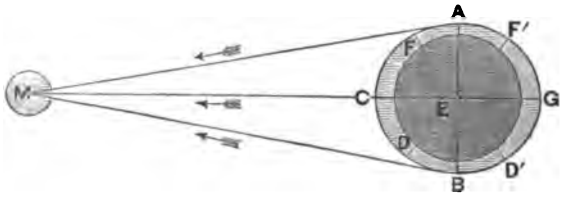
5. **The Force of Waves.**—The violence of waves is at times very great. During a storm on the western coast of Scotland, in March, 1845, the force of the waves was estimated at 6000 pounds on the square foot. In the Hebrides, a rock weighing forty-two tons was moved, in the height of the gale, several feet by the waves. Over the Eddystone Rock, in the English Channel, the sea breaks at times with tremendous violence. Three light-houses have been successively erected; the first two were swept away by the sea. The present structure has withstood hitherto all the fury of the elements; though the waves have been seen to break over its top in cataracts of foam to the height of 150 feet above the sea-level.

TIDES.

6. **Tides** are the alternate rise and fall of the ocean twice in the course of a lunar day (twenty-four hours fifty-one minutes). The waters of the sea rise for the space of about six hours, overflowing the shores and running into the channels of rivers: this is the *flood tide;* and when they have attained their highest elevation, *high tide* occurs. Remaining at this height for a few minutes, the waters then begin to fall, and continue to sink for about six hours more: this is *ebb tide;* and when they have reached their greatest depression, it is *low tide.* After attaining this point, they soon begin to rise again; and thus from year to year, and from century to century, the ebb and flow of the ocean follow each other at regular intervals of time.

From this explanation it will be readily seen that there are daily two *high tides* and two *low tides.* The interval of time between two successive high or low tides is twelve hours twenty-five and one-half minutes: accordingly, when there is a high tide at any place, there must at the same time be also another high tide on the opposite side of the globe; and the same is true in respect to low tides.

7. **Cause of the Tides.—Lunar Tides.**—The *unequal* attraction of the moon and sun upon different parts of the globe produces the tides; and we will now explain the action of the moon. In the annexed figure, M represents the moon, the circle E the solid portion of the earth, and the light ring ABCG the surrounding ocean. Every particle of matter composing the earth is attracted by the moon, but this attraction is less as its distance from the moon is greater. This force cannot, however, change the form of the solid portion of the globe, for its atoms are bound together in a mass; but the watery particles are free to move and obey this influence. At C this force is greatest, decreasing on either side towards F and D; and the waters are, consequently, heaped up around C. The solid part of the earth is more attracted than the waters at G, as it is nearer to the moon, and the effect is as if the former were drawn toward the moon, leaving the water heaped up around G. Thus the two simultaneous high tides are produced. At A and B the moon acts obliquely upon the ocean, depressing its waters; and at these points low tides occur.

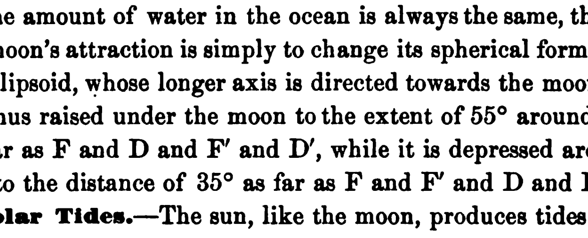


HIGH AND LOW TIDES.

As the amount of water in the ocean is always the same, the effect of the moon's attraction is simply to change its spherical form to that of an ellipsoid, whose longer axis is directed towards the moon. The sea is thus raised under the moon to the extent of 55° around C and G, as far as F and D and F′ and D′, while it is depressed around A and B to the distance of 35° as far as F and F′ and D and D′.

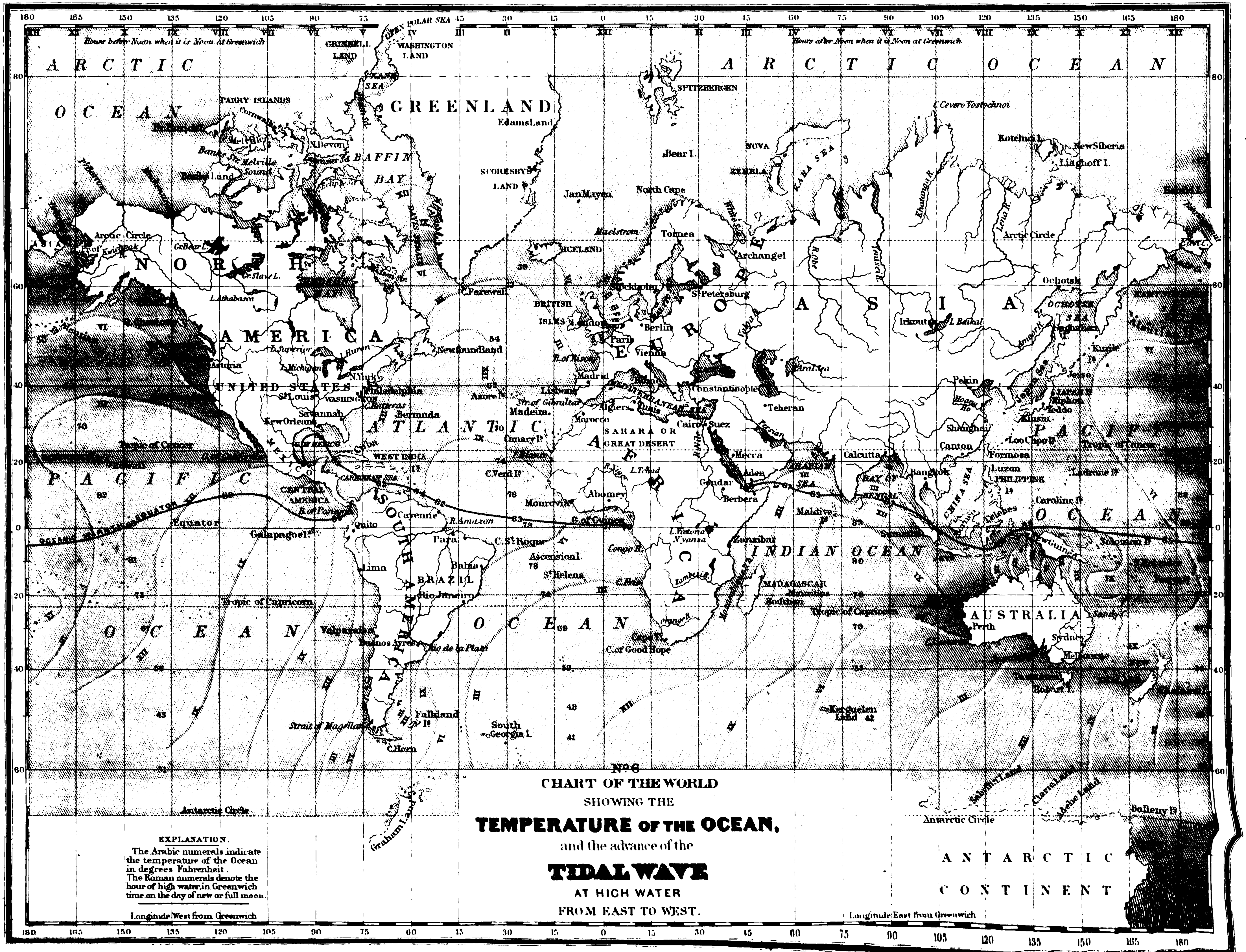
8. **Solar Tides.**—The sun, like the moon, produces tides in the ocean, but of less height; for, on account of its great distance, its inequality of attraction upon the different parts of the globe is less than that of the moon, and it is this inequality which gives rise to the phenomenon of tides. The lunar tide-wave is about two and a half times greater than the solar.

9. **Spring and Neap Tides.**—The sun and moon produce tides independently of each other; but, as their relative positions are constantly changing during every month, their separate actions are alternately united and opposed to each other. Twice a month—at new and full moon—the sun and moon *act together,* and the tides are then unusually high, since the solar and lunar tides are then heaped one upon the other. These are the *spring tides.*



SPRING TIDE.

What is said of the surf at Madras? Does the sea rest at once after a storm? How far are the undulations caused by a storm sometimes propagated? What is the ground-swell? 4. Give an account of earthquake-waves, and mention those of Simoda. 5. What is said respecting the force of the waves? Give the instances cited. 6. Define tides. What is meant by the flood, high, ebb, and low tides? What is the interval of time between two successive high or low tides? 7. Explain in detail the cause of tides. 8. How is the solar tide caused? Why is the lunar tide greater than the solar? 9. What are the spring and neap tides?



No. 6

CHART OF THE WORLD

SHOWING THE

TEMPERATURE OF THE OCEAN,

and the advance of the

TIDAL WAVE

AT HIGH WATER

FROM EAST TO WEST.

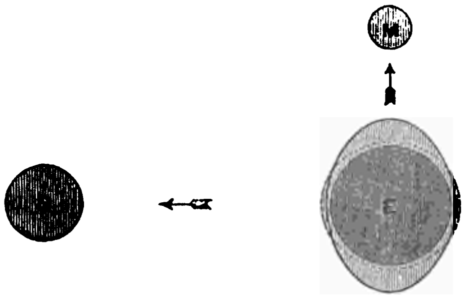
EXPLANATION.

The Arabic numerals indicate the temperature of the Ocean in degrees Fahrenheit.
The Roman numerals denote the hour of high water in Greenwich time on the day of new or full moon.

Drawn & Engraved by J. H. Alcock

Twice every month—at the first and third quarters of the moon—**the sun** and moon *oppose* each other; for where the action of the **former** then tends to elevate the waters, that of the latter depresses **them, and** where the moon raises the surface of the ocean, the sun **causes it** to sink. These are the *neap tides.* The relative heights of **the spring** and neap tides are as seven to three.

The annexed figures **illustrate** the subject of **the spring** and neap tides. **In each** of these figures **S represents** the sun, M **the moon**, and E the solid **portion** of the earth. The **dotted** line enclosing the **earth** is the boundary of **the** solar tide-wave; upon **this** is heaped the lunar tide-wave, bounded by the outer curved line.



NEAP TIDE.

10. **Nature of the Tide-Wave.**—While the wind-waves disturb **the** sea only to the depth of a few feet, the tide-wave affects it from **the** surface to the bottom. If the globe were entirely covered by **water**, the phenomenon of the tides would be far less complicated. **Then** the great tide-wave would be seen following the moon in **her** daily apparent revolution from east to west around the globe, **its** crest ranging in a northerly and southerly direction. Now, this wave is crossed in its path by vast continents, and its undulations are propagated along extended shores and around projecting capes and headlands, which arrest and change its course. Thus, the Atlantic tides can reach the Pacific only through Behring Strait, thirty-six miles wide, and by passing around Cape Horn, to the south of which lies a chain of islands which narrows the tidal channel to the breadth of about 500 miles. Its progress is also retarded by the varying depth of the ocean; for the velocity of a wave depends, as we have seen, upon the depth of water through which it moves.

11. **Cotidal Lines.**—The phenomenon of tides is extremely complex, and is to be ascertained principally from observation. These results are delineated on maps by drawing lines through the places where high water occurs at the same moment of absolute time at new and full moon. These are termed cotidal lines. Thus, in the map of the Temperature of the Ocean, page 80, the curved line marked IX, which passes through New Zealand and the Solomon Isles, shows the crest of the high tide at nine o'clock Greenwich time; and so of other lines.

12. **Origin, Progress, and Velocity of the Tide-Wave.**—The results of the researches upon tides show that this phenomenon has its origin in the vast oceans that girdle the south pole, the great tidal wave first appearing not far from the western shores of South America. The tide here raised by the sun and moon seeks to follow these luminaries around the globe in their apparent westerly course, at the rate of about 1000 miles per hour; but the varying depths of the ocean materially check its progress.

In order to trace the progress of the tidal wave, let us imagine that high water occurs off the west coast of South America at one o'clock on a Monday afternoon, on the day of new or full moon. About eleven o'clock at night the tide-wave will reach Kamtschatka, having traversed the deep waters of the North Pacific at the rate of 850 miles an hour. Two hours later, at one o'clock on Tuesday morning, it will be high water at New Zealand; and at about six o'clock in the afternoon of the same day the tidal wave will pass the Cape of Good Hope. Entering the Atlantic, and sweeping northward at the rate of about 700 miles an hour, it will arrive at the shoal waters of the coast of the United States at five o'clock on Wednesday morning, and six hours later will reach Iceland.

13. **Time of the Tide.**—If the waters of the ocean moved with perfect freedom, the tide-wave sweeping around the globe would keep directly under the moon, and it would be highest at any place when the moon was on the meridian of that place. But the waters do not obey at once the action of the moon, on account of their inertia; and they are also retarded by the friction produced by their passage over the bed of the sea and along the sides and over the bottom of channels. It thus happens that high tide does not occur at any place until several hours after the moon has crossed its meridian. This interval varies in different places: at Dunkirk, high tide occurs twelve hours after the moon has passed its meridian; and at the Cape of Good Hope, an hour and a half after the passage of this luminary.

14. **Height of the Tide.**—On shores of islands in the midst of the great oceans, the tides rise but little above the sea-level,—sometimes less than a foot; and the average height for the islands of the Atlantic and Pacific is about three and a half feet. On the shallows of coasts, where the tide moves slowly and the waters are retarded, the average altitude is from four to five feet. But when the tide-wave rushes up a bay or through a narrow channel, it rises to a surprising height. Thus, at the entrance of the Bay of Fundy the rise of the tide is eighteen feet, and at its head it sometimes reaches the altitude of seventy feet; and within the British Channel the wave is so compressed that at St. Malo, on the coast of France, the height of the tide is fifty feet.

15. **Derivative Tides.**—The tides perceptible in rivers and in seas communicating with the ocean are called *derivative tides,* inasmuch as they are portions of the great oceanic wave which flows from the open sea. The derivative tides ascend large rivers to a great distance from their mouths; but their upward progress is so much retarded by their friction against the land, and various other impediments which they encounter, that several tides, in some instances, are found at the same time in the same river. When the tide enters suddenly the mouth of a river abounding with shoals, it checks the flow of the stream, and a high wave, called a *bore,* rushes up the river. In large rivers, immense waves of this kind are formed. In the Amazon, at the equinoxes, when the equatorial tides are the highest, five bores, from twelve to fifteen feet high, are found simultaneously advancing up the stream during three successive days. The bore of the Tsientung, in China, sweeps up the river as a wall of water thirty feet high, with a velocity of twenty-five miles per hour.

16. **Tides of Lakes.**—The attractive force exerted by the moon upon the waters of a lake is so nearly the same in every part of it that the sensible difference is very small, and, consequently, the tide must be very slight; for it is produced by the difference and not the amount of attraction. Still less will be the difference in the case of the sun. From observations made at Chicago in 1859, it has been proved that Lake Michigan possesses a tide having an average height of one and three-quarter inches. No tide has as yet been detected in the Caspian Sea.

When do they occur, and how are they caused? 10. Explain the nature of the tidal wave, and how its progress is retarded. 11. What are cotidal lines? 12. Give an account of the origin, progress, and velocity of the tidal wave. Give the illustration of its westward advance. 13. What is said respecting the time of the tide at any place in reference to the position of the moon? 14. What is the mean height of the tide in the midst of the great oceans? What is the average height in the shallow waters of coasts? Where do tides rise to great altitudes? Give the instances cited. 15. Explain the subject of derivative tides. What is a bore? 16. What is said respecting the tides of lakes?

OCEAN-CURRENTS.

17. The *third* grand movement of the Ocean is its currents, which are vast marine streams flowing through the sea and mingling together the waters of different climes.

Unlike the rivers of the land, they move, for the most part, in a ceaseless circuit, returning to the regions whence they started. In some cases, a vast extent of ocean is embraced within their circuit; in others, the opposite branches of the current flow side by side; or one may traverse the deep sea, while the other flows above it.

18. **Origin.**—Their origin is attributed to the rotation of the earth, to the difference in the densities of the waters of the polar and tropic seas, to the immense evaporation from the latter, to winds, tides, the melting of polar ice, and various lesser causes.

Currents are naturally divided into *constant*, *periodical*, and *local;* inasmuch as some arise from influences that are constant in their operation, others from those that are variable, and some from local causes.

In reference to their *position*, they are termed *marine* and *submarine*,—the former flowing at the surface of the sea, and the latter far below it. Currents produced by the action of constant and prevailing winds are called *drift* currents. A *counter-current* is one that flows in a direction opposite to that of the main current.

19. **Constant Currents.**—These are by far the most important; and though philosophers are by no means agreed, either as to all the causes that produce them, or in respect to the importance to be attributed to the several assigned causes, they are generally explained as follows. By the intense action of the sun, the waters of the sea in the torrid zone are highly heated, and become lighter than in other parts of the ocean; and from this region also a vast amount of water is abstracted by the excessive evaporation which here occurs.

To supply this loss, and to displace the warm and lighter water, the cold and heavier waters of the polar seas flow north and south towards the equator. But the globe revolving on its axis from west to east, all objects upon it move easterly with different velocities in different latitudes, the speed increasing from the poles to the equator.

The currents that flow from the poles towards the equator are constantly passing into regions that have a higher easterly velocity than themselves, and this velocity, on account of their own inertia, they cannot at once acquire: they therefore lag behind, or—what is the same—acquire a relative westerly motion.

The current that sets towards the equator from the north pole moves, therefore, to the west at the same time, and becomes a southwest current; and that from the south pole, a northwest current. For similar reasons, the currents proceeding from the equator towards the poles flow to the northeast in the Northern Hemisphere, and to the southeast in the Southern.

According to Lieutenant Maury, the enormous evaporation in the tropic seas makes the surface-water salter and heavier than in other tracts of the ocean; while in the polar seas the excess of fresh water which they receive, in the form of rain, snow, and hail, over what is evaporated, renders their waters less salt and lighter than those of other latitudes. Thus there exists, according to his views, a surface-current from the poles to the equator, containing less salt than usual, while in the tropics the heavier and salter water, sinking down into the depths of the sea, flows beneath the former as a submarine current towards either pole.

The courses which the great constant currents tend to pursue are identical with those of the constant and prevailing winds of the tropical and extra-tropical regions. (See page 93.) The constant trade-winds within the tropics, acting upon the sea, drive the surface-water along, producing a current tending towards the southwest in the Northern Hemisphere, and towards the northwest in the Southern. According to the high authority of Sir John Herschel, who discredits the effects of evaporation, varying temperature, and saltness, the majestic Gulf Stream owes its origin entirely to the action of the trade-winds; and he asserts that, if there were no atmosphere, neither this nor any considerable oceanic current whatever would exist.

These four primary currents,—viz., the two polar and the two equatorial,—broken up and modified by their action on each other, by the configuration of the coasts upon which they strike, by the form of the ocean-bed, by inequalities of temperature, and by other causes, give rise to the numerous streams that constitute the great circulating system of the ocean. This system will now be described as delineated in the chart of the Ocean-Currents.

20. **Arctic Current.**—This current, which originates in the Arctic Ocean, flows southward along the eastern coast of Greenland. It unites in about 50° north latitude with two other cold currents, coming down from the west coast of Greenland and from Hudson Bay.

The stream now, advancing southward to Newfoundland, sends off a branch through the Strait of Belleisle into the Gulf of St. Lawrence; while the main current continues its course till it encounters the Gulf Stream in about 43° north latitude. Here it divides into two branches, one of which, flowing along the coast of the United States as far as Florida, by the side of the Gulf Stream, forms the counter-current of the latter; while the other, running southward beneath the Gulf Stream as a submarine current as far as Florida, enters the Caribbean Sea, the waters of which below the surface are found to be as cold as those off the shores of Spitzbergen at corresponding depths. Numerous icebergs are borne down to the warmer climes by the Arctic current. Five hundred were seen at one time by Captain Scoresby.

21. **The Atlantic Equatorial Current.**—This current originates near the equator, and flows westward from Africa towards America. Near Cape St. Roque it separates into two branches, one of which flows to the southwest along the shores of Brazil and by the coast of Guiana into the Caribbean Sea, and the other to the northwest. The length of this current, from Africa to the Caribbean Sea, is 4000 miles; its breadth at the commencement is 160 miles, which increases to 450 miles where it divides; its average velocity is about thirty miles a day, and its temperature 75° Fah., or from 4° to 6° below that of the surrounding ocean. The southwest branch, or Brazilian current, flows at the distance of from 250 to 300 miles from the coast, with a velocity of twenty-five miles a day, and blends, according to Dana, with the South Connecting current: the same eminent authority makes the latter stream to extend along the east coast of South America beyond 40° south latitude, and to turn northward after joining the Antarctic current. Advancing towards

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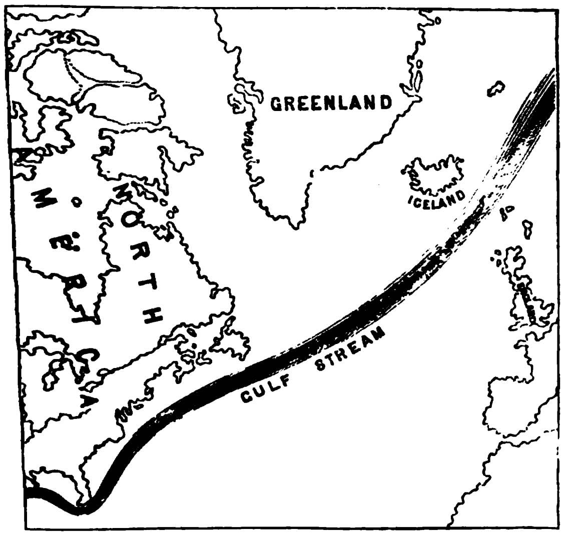
17. What is the third grand movement of the ocean? What are they? Compare the marine with the land rivers. 18. How are currents produced? How are they classified as respects their origin? Why are they so called? How classified in regard to position? What are drift and counter currents? 19. What is said of constant currents? How are they generally explained? What are Lieutenant Maury's views? What is said respecting the direction of the marine and atmospheric constant currents? What are Sir John Herschel's views in regard to oceanic currents? What is said respecting the four primary currents? 20. Describe the Arctic current. 21. Describe the Atlantic Equatorial current, with its branches.

the north, part of its waters unite with the South Atlantic current, **while the** rest continue on and enter the Indian Ocean. The second **and most** noted branch of the Equatorial current, skirting the coast **of Guiana,** with a velocity varying from twenty to thirty-six miles a **day, at** length enters the Caribbean Sea, its strength and volume **having** been increased by the influx of the waters of the Orinoco. **Flowing** through this sea, which Rennel calls a sea in motion, this majestic current sweeps around the Gulf of Mexico, and, passing between **Florida** and the isle of Cuba, is then known as the Gulf Stream.

22. **Gulf Stream.**—This is one of the most remarkable and important of all the ocean-currents, and has been more fully explored than any other. Its waters are of a dark indigo color, of so marked a hue that their line of junction with the ocean is distinctly traced by the eye. Deep and narrow, it runs by Florida with a velocity varying from two to five miles an hour, and, pressed by the cold current between it and the shore, flows parallel to the coast as far as Cape Hatteras. Meeting beyond this point shoals, the banks of sand extending as far as Newfoundland, it there turns abruptly to the east, and, with diminished speed and increased width, rolls onward towards the coast of Europe. Ere long it divides into two great branches,—the northern and southern. The former, under the action of the prevalent southwest winds, extends as far as Spitzbergen, sending off a minor shoot through the Bay of Biscay. The latter, sweeping along by the Madeira and Canary Islands, and driven by the northeast trades, returns to the equator, completing the circuit.



GULF STREAM.

Within the vast area thus encircled is the Atlantic Sargasso, or *Grassy Sea*, where the surface of the ocean, between 20° and 65° west longitude and 18° and 28° north latitude, is covered with sea-weed, and in places is so densely matted with marine plants that the water is concealed.

Temperature.—The maximum temperature of the Gulf Stream at the surface occurs off the coast of Florida. It is here 86° Fah., or about 9° Fah. higher than that of the ocean in the same latitude. Increasing its latitude 10°, it loses but 2° Fah. in temperature, and retains its warmth far below the surface; for on a winter's day, off Cape Hatteras, its temperature was found by the Coast Survey to be 57° Fah. at the depth of 3000 feet. From Cape Hatteras to the Grand Bank of Newfoundland the stream is warmer than the ocean by 20° or 30° Fah. After flowing 3000 miles to the north, this stream still preserves, even in winter, a summer heat, and, inundating with its warm water the cold surface of the sea for thousands of leagues, forms a constant reservoir of heat, which, borne by the prevailing southwesterly winds to Europe, softens the rigor of its climate. It has been estimated that the amount of heat arising from the Gulf Stream on a winter's day is sufficient to raise the atmosphere over the British Isles from the freezing-point to a summer temperature. The Gulf Stream, as already stated, flows over a cold submarine current, and is bounded on the shore-side by the cold counter-current, forming what has been termed the *cold wall*. Alternate bands of warm and cold water are also found near and within the Gulf Stream.

It may be asked, How does the Gulf Stream retain its warmth while flowing through a sea which is colder? To this it is answered that a fluid in motion can pass through a fluid of the same kind in repose and having a different temperature, without suddenly changing its own temperature. A warm current thus preserves its heat while flowing through a cold sea, and a cold current its low temperature while traversing a warm sea.

23. **North African, Guinea, and South Atlantic Current.**—This originates in the Atlantic, opposite France, and, flowing south, a portion of its waters sets into the Mediterranean. Beyond the Strait of Gibraltar it follows the line of the African coast, till, meeting the Equatorial current, it flows by its side for the space of 1000 miles. Its breadth opposite Cape Palmas is 180 miles, and its velocity varies from twelve to fifty miles a day. Beyond this is the South Atlantic current, which, according to Dana, flows northward off the southwestern shores of Africa.

24. **Antarctic Drift Current.**—From the vast oceanic expanse around the south pole an immense current of cold water sets towards the equator. This is the Antarctic Drift current. In the Pacific it flows in a northeasterly direction towards the coast of South America, where it divides into two branches,—the Humboldt or Peruvian, and the Cape Horn current.

The former, which was discovered by Humboldt in 1802, flows northward along the coasts of Chili and Peru to about 20° south latitude, when it turns suddenly to the northwest, expanding in width, and unites with the great Equatorial current of the Pacific. Its temperature for more than 400 miles of its course is from 12° to 14° Fah. below that of the incumbent atmosphere, and from 8° to 10° Fah. below that of the waters of the ocean through which it passes. Its velocity from Valparaiso to Lima varies from twelve to eighteen miles per day; while at the Galapagos Islands it ranges from seventy to one hundred and twenty miles daily.

The Cape Horn current sweeps in a northeasterly course around Cape Horn and the Falkland Islands, and probably joins the South Connecting current of the Atlantic. Its velocity varies from fifteen to fifty-six miles a day, and it preserves its low temperature as it traverses the ocean.

Other portions of the Antarctic current flow northeasterly as far as Australia and New Zealand, joining the warmer current around those islands. The area over which the Antarctic current extends is one of prevailing westerly winds, which impart to this ocean-stream its easterly direction. It brings down icebergs from the regions around the south pole; and the limits to which they drift are those seen upon the map.

25. **Equatorial Current of the Pacific.**—This great current, 3500 miles broad, flows westward for a distance of 9000 miles, from South America to the shores of Asia, with a velocity of from twenty to

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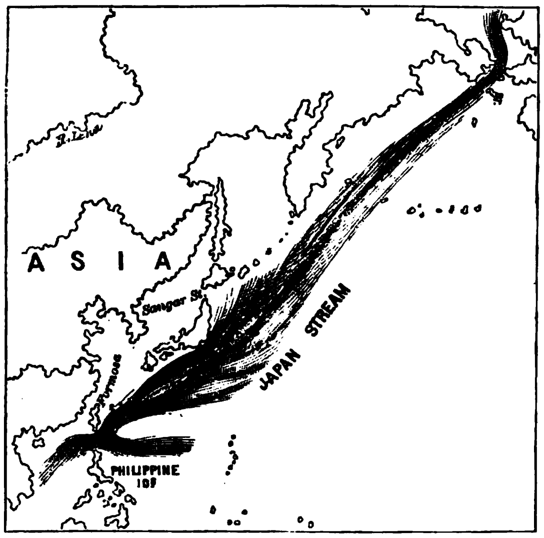
22. Describe the Gulf Stream. What is the Sargasso, or Grassy Sea? State what is said of the temperature of the Gulf Stream. What effect has this stream on the climate of Europe? What estimate has been made? Why does this stream retain its warmth? Why will a cold current retain its low temperature in flowing through a warm sea? 23. Describe the North African, Guinea, and South Atlantic current. 24. Describe the Antarctic Drift current. What are its main branches? Describe them. 25. Describe the Equatorial current of the Pacific.

sixty miles a day. By the Polynesian islands it is split up into innumerable streams, but near the Indian Archipelago it divides into two main branches, one of which sets southward along the coast of Australia, meeting the Antarctic current from the south; while the other, more decided in its character, turns northward, and flows along the coast of Asia, under the name of the Japan current,—which deserves especial mention.

26. **Japan Current.**—From the investigations made by Lieutenant Silas Bend, of the Japan Expedition under Commodore Perry, it appears that this current (called by the Japanese the *Kuro Siwo*, or Black Stream, from the deep-blue color of its waters) resembles in many respects the Gulf Stream of the Atlantic.



JAPAN CURRENT.

Near the south end of the island of Formosa, 22° north latitude, this stream is separated from the Pacific Equatorial current, and flows northward along the southern shores of the island, where its character is as decidedly marked as that of the Gulf Stream. In 26° north latitude, it turns towards the east, flowing along the whole southeastern coast of Japan to the Strait of Sangar, its strength increasing with its progress, till it approaches the Gulf of Yeddo. Here its greatest velocity is attained, which varies from seventy-two to eighty miles a day; while from Formosa to the Strait of Sangar its average daily rate is from thirty-five to forty miles. Near its origin the Kuro Siwo has a breadth of 100 miles; but to the north its southern limit expands till it attains a width of 500 miles.

Between the Kuro Siwo and the coast a cold current intervenes, as in the case of the Gulf Stream and the Atlantic coast. This cold stream, it is believed, is a counter-current flowing from the Arctic Sea, which finds its way by the Japan Sea and the Formosa Channel into the China Sea. The temperature of the Japan current is about the same as that of the Gulf Stream; but, while the waters of the latter are only 9° Fah. warmer than the ocean-temperature due to the latitude, those of the former are 12° Fah. higher. In the Kuro Siwo, tracts of floating sea-weed were observed, similar in appearance to those of the Gulf Stream, and alternate bands of warm and cold water were likewise discovered. In the North Pacific, fogs and mists prevail, the Aleutian Isles being as remarkable for fogs as the Banks of Newfoundland.

Near the Kurile Isles, the Japan current sends off a branch to the north, called the Kamtschatka current, which enters the Arctic Sea through Behring Strait; while the main stream sweeps eastward, under the name of the North Pacific Drift current.

27. **North Pacific Drift Current.**—This ocean-stream, the counter-current of the Pacific Equatorial, passes across the North Pacific, then, turning southward, skirts the shores of Northwestern America, and softens by its warmth the rigors of this clime. At length it bends to the west, and completes its immense circuit by merging in the Equatorial stream. A minor branch is sent off along the coast, called the California current, which is prolonged from December to April by the Mexican current, produced by the monsoon.

28. **Trade Drift Current.**—In the Indian Ocean the Equatorial or Trade Drift current is less marked than in the Pacific. It has its origin to the southwest of Australia, and, first running northward with a velocity of from twenty to thirty miles a day, it turns to the west after passing the Tropic of Capricorn, and flows towards Africa. At Madagascar it divides into two branches, one of which, passing around the north of the island with a velocity of from forty-five to sixty miles a day, flows southward between the island and the mainland, under the name of the Mozambique current, the strongest in the Indian Ocean. The other branch, which is broader and more feeble, bends southward, and at length unites with the former, constituting the Cape current.

Cape Current.—This stream, 100 miles broad, with a temperature of 7° or 8° Fah. above that of the ocean, runs towards the Cape of Good Hope at the rate of sixty or eighty miles a day.

At the Cape it divides, one branch passing the Cape and blending with the Atlantic currents; the other, obstructed by the Agulhas Bank, is turned back, and, combining with the Antarctic current, forms the counter-current of the Trade Drift. This counter-current is of great service to commerce, being in the direct route from the Cape to Australia, and flowing near the Agulhas Bank with a velocity of fifty miles a day.

29. **Periodical Currents.**—These currents are chiefly caused by the monsoons, which are periodical winds that prevail within and near the tropics and blow half the year in one direction and the other half in the opposite. Local causes, however, greatly modify their course. The principal currents of this kind are the Bengal and Red Sea currents in the Indian Ocean, and the East Australian, Caroline, and Mexican currents in the Pacific.

The Bengal current flows northeasterly along the Coromandel or eastern coast of India during summer, when the southwest monsoon prevails, and in the opposite direction in winter, the season of the northeast monsoon,—being entirely dependent upon the monsoons. Its velocity is greatest in winter, when its speed is fifty miles a day. Sweeping then around Cape Comorin and the island of Ceylon, it joins the currents of the Maldive Islands and the Malabar coast, and sets westerly, its direction, however, depending upon the northeast monsoon.

The Red Sea currents are entirely dependent upon the direction of the wind, flowing northerly when south winds prevail, and southerly during the time of the north winds. Hardly any current is perceived when the winds are changing and the atmosphere is but slightly disturbed; but when the wind is strong, the velocity of the current is from twenty to forty miles per day. From May to October the waters of this sea are two feet lower at the northern than at the southern end,—an effect due to the north winds, which then drive the waters of the sea through its narrow outlet into the Gulf of Aden. (Lieutenant Maury, however, attributes this phenomenon to the excessive evaporation which then occurs.) During the other part of the year, when the south winds prevail, the reverse is the case, the waters of the sea being higher at its northern end.

In the vicinity of the Caroline Isles, the central portion of the

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26. Describe the Japan current. 27. Describe the North Pacific Drift current and its offset. 28. Describe the Trade Drift current and its branches. 29. What are periodical currents? Name the principal periodical currents. Describe the Bengal and Red Sea currents.

Pacific Equatorial is influenced by the monsoon, and flows west in summer and east in winter, causing the Caroline Monsoon current.

The East Australian current extends along the east coast of Australia from 20° south latitude to Tasmania, and is dependent upon the winds. It flows south in summer and north in winter, with a velocity of from twenty to thirty miles a day.

The Mexican Coast current, first described by Humboldt, is dependent on the monsoon,—flowing southeasterly during the winter and northwesterly in the summer.

30. **Local Currents.**—Dangerous local currents are caused by the tides in various places, where, from the peculiar configuration of the land, the advancing wave is driven through narrow and tortuous channels. Such is the Roost of Sumburgh, at the south promontory of the Shetland Isles, where the current runs at the rate of fifteen miles an hour.

These currents sometimes meet, causing a whirlpool, as in the case of the celebrated Maelstrom, which is produced by the conflict of tidal currents around the islands of Logodoën and Moskoë. Although it has been clothed with fabulous terrors, like the Charybdis of the ancients, it is in reality a terrific vortex. An intelligent American seaman, about forty years since, sailed through the margin of the Maelstrom, and described it as follows:—"While navigating a ship from North Cape to Drontheim, I inquired of my Norway pilot about the practicability of running near the whirlpool. He told me that with a good breeze it could be approached near enough for examination with safety. I at once determined to satisfy myself, and at ten o'clock A.M. on a fine September day we began to approach it, having a fine breeze from the northwest. I went at once on the maintopsail-yard, with a good telescope, and had scarcely seated myself when the ship entered the dish of the whirlpool, the velocity of which immediately altered the course of the ship 33° 45′ towards the centre, although the vessel was sailing at the rate of eight miles an hour.

"I now saw before me an immense circular stream, a mile and a half in diameter, as concave as the waters of a funnel when half run out, its velocity increasing as it approached the centre, and gradually changing its dark-blue color to white as it rushed foaming to the vortex. Over all rose the hissing and roaring of the battling waves, presenting at once the most awful, grand, and solemn scene I ever experienced. Of such strength and magnitude is the whirlpool, that I doubt not instant destruction would be the fate of a dozen of our largest ships, were they drawn in at the same moment. The pilot says that several vessels have been thus engulfed, and large whales destroyed. The first statement I think probable enough, but rather doubt the latter."

31. **Submarine Currents.**—Submarine currents have been discovered in various parts of the ocean. The great polar current that underlies the Gulf Stream has been better explored than any other, and its existence clearly proved by numerous thermometrical soundings, which have been made throughout its entire course.

An under-current flows out into the Atlantic at the Strait of Gibraltar, as is clearly shown by the following incident. In the year 1812, a French privateer gave chase near Ceuta to a Dutch ship, and, coming up with her in the strait between Tarifa and Tangier, sunk her with one broadside. A few days afterwards the ship arose on the shore near Tangier, four leagues to the west of the place where she sank, while the current at the surface was flowing eastward.

The power of these submarine currents is often tremendous, as is shown by the progress of icebergs forcing their way against the wind and surface-current through the ice-fields of the polar seas. These stupendous masses sink about eight times deeper below the surface than they rise above it, and the under-currents thus act upon them with greater power than the winds and upper currents. An officer connected with the Grinnell Expedition states that, on one occasion, while the vessels were endeavoring to advance northward against a strong surface-current setting south, an iceberg, with its top many feet above the water, came drifting from the south, and passed them "like a shot."

Captain Duncan, of the English whaler Dundee, speaks of the awful sublimity of the scene which he witnessed in the polar seas, as he beheld immense icebergs crashing through the vast ice-fields with resistless power, in obedience to the force of the under-current.

There is reason to believe, according to Lieutenant Maury, that these under-currents exist in nearly all parts of the deep sea; and a simple apparatus has been employed in the United States navy to detect their presence. A block of wood, so loaded that it sinks, is let down to the depth of from six hundred to two thousand feet, and then sustained by a float. The float is then seen, where there is a submarine current, working its way against the wind and surface-current at the rate sometimes of more than a mile an hour.

32. **Utility of the Ocean-Currents.**—Scarcely any thing else in the structure of the globe so grandly reveals the beneficent wisdom of the Creator as the great oceanic currents. Far back in the past they have greatly influenced the condition of the world; and without them, man could not exist. The blessings they confer relate principally to climate, commerce, the distribution of animal and vegetable life, and health.

The ocean-currents modify the extremes of different climes, tempering the excessive heat of the equatorial regions and softening the rigorous climates of the higher latitudes. The sun raises the waters of the ocean in the torrid zone to a very high temperature, which would make the climate of the adjacent lands intolerable, if these hot waters were not borne away to distant regions and their place supplied by cooler streams. And towards those higher latitudes which have furnished these icy currents, sets the vast equatorial river, charged with its surplus heat, driving back the frost and ice towards either pole, curbing the limits of their domain, and filling with life and beauty many a region which else would have been silent and desolate.

Tracing out the various branches of the equatorial currents in the different oceans, it is seen that they all tend to diffuse warmth through the colder climes, while, on the other hand, the Antarctic and Arctic currents bring down their grateful coolness to the hot regions of the globe. The islands of the Pacific and the shores of Chili and Peru feel the influence of the first, while the burning clime of Central America is tempered by the cool waters of the Arctic stream. Such is the benign and beautiful provision of the Creator for moderating the extremes of climate. Under the subject of Meteorology a similar system will also be unfolded, tending to the equalization of the temperature of the globe.

In the infancy of commerce, when the system of ocean-currents was unknown to mariners, their influence was, doubtless, more disastrous than beneficial, ships being frequently carried upon rocks and shoals by their unsuspected power. But now, when the sea has

Describe the Caroline, East Australian, and Mexican currents. 30. How are local currents caused? What is said of the Roost of Sumburgh? Describe the Maelstrom. 31. State what is said respecting submarine currents. 32. What is said of the utility of the ocean-currents? In what particulars are they beneficial? State what is said of their influence on climate. Describe the effect of currents on commerce.

become better known, their agency is pressed into the service of man, just as the lightning, once a source of unmitigated terror, is now his servant and bears his messages over continents and oceans. By the aid of ocean-charts, mariners are now enabled to take advantage of favorable currents and to avoid those that are adverse, thus shortening their voyages and facilitating the commerce of the world.

In the Indian Ocean, a ship sailing from Java homeward-bound to Europe is borne westward by the Equatorial currents at the rate of from ten to twenty-four miles a day, and, after passing Madagascar, is carried southwesterly at the speed in some places of 120 miles a day. The influence of the Gulf Stream upon commerce and navigation is very remarkable. Up to nearly the close of the last century, its practical advantages were scarcely known, though it had been constantly navigated since the days of Columbus. The American sailors, indeed, were then aware of the current of this stream, and, by avoiding it, made quicker voyages from Europe to America than the English mariners, who, ignorant of the current, kept within it, and were set back sixty or seventy miles a day. Dr. Franklin, in 1775, was the first to suggest that the difference in temperature between the waters of the Gulf Stream and the adjacent ocean was so marked that it would afford a sure means of ascertaining the position of a ship at sea. This variation is now employed as an unerring sea-mark, indicating to all vessels that approach our dangerous northeastern coast, their proximity to the land. And when the wintry storms, laden with sleet and snow, fall upon the struggling bark, casing her in ice from the deck to the mast-head, the half-frozen crew direct her course to the Gulf Stream. Once entered, an almost tropic sea is beneath her keel, her icy covering melts away, and the bland and genial airs of summer invigorate and cheer the suffering mariners.

According to Lieutenant Maury, since the application of the thermometer to the Gulf Stream the average passage from England by sail has been shortened from eight weeks to a little more than four.

The constant currents of the ocean, in connection with the constant winds, bear their part in the distribution of animal and vegetable life. Immense collections of floating wood are gathered around the north coast of Iceland, and the productions of the vegetable kingdom have been widely spread by the seeds which these ocean-rivers have disseminated to regions far distant from each other. The Gulf Stream frequently brings quantities of tropical seeds to the shores of Ireland, the Hebrides, and Norway. On the spacious icebergs, animals have been carried to new climes and homes; and, driven out to sea by adverse winds, canoes with their human freight have been borne by these powerful currents to the mid-ocean, and the lone islands of the sea have thus at times been colonized. That such events are possible, has been proved by the fact that the wreck of a Japanese junk was recently drifted, with its surviving crew, as far as the Sandwich Islands, completing nearly half the great circuit of the currents of the North Pacific.

33. **Health.**—The great movements of the ocean, its mighty currents, its tides and waves, all conspire to render this most important part of the globe pure and healthful. "Without them," says a learned writer, "the sea, charged with an immense amount of decomposing vegetable and animal matter, would become a stagnant, fetid pool, reeking with noxious exhalations, infecting the whole atmosphere, and reducing the habitable parts of the earth to the condition of a desert."

What is said of the influence of currents in respect to the distribution of animal and vegetable life? 33. What effect have the oceanic motions on the health of the world?

REVIEW AND MAP QUESTIONS ON WAVES, TIDES, AND OCEAN-CURRENTS.

WAVES.

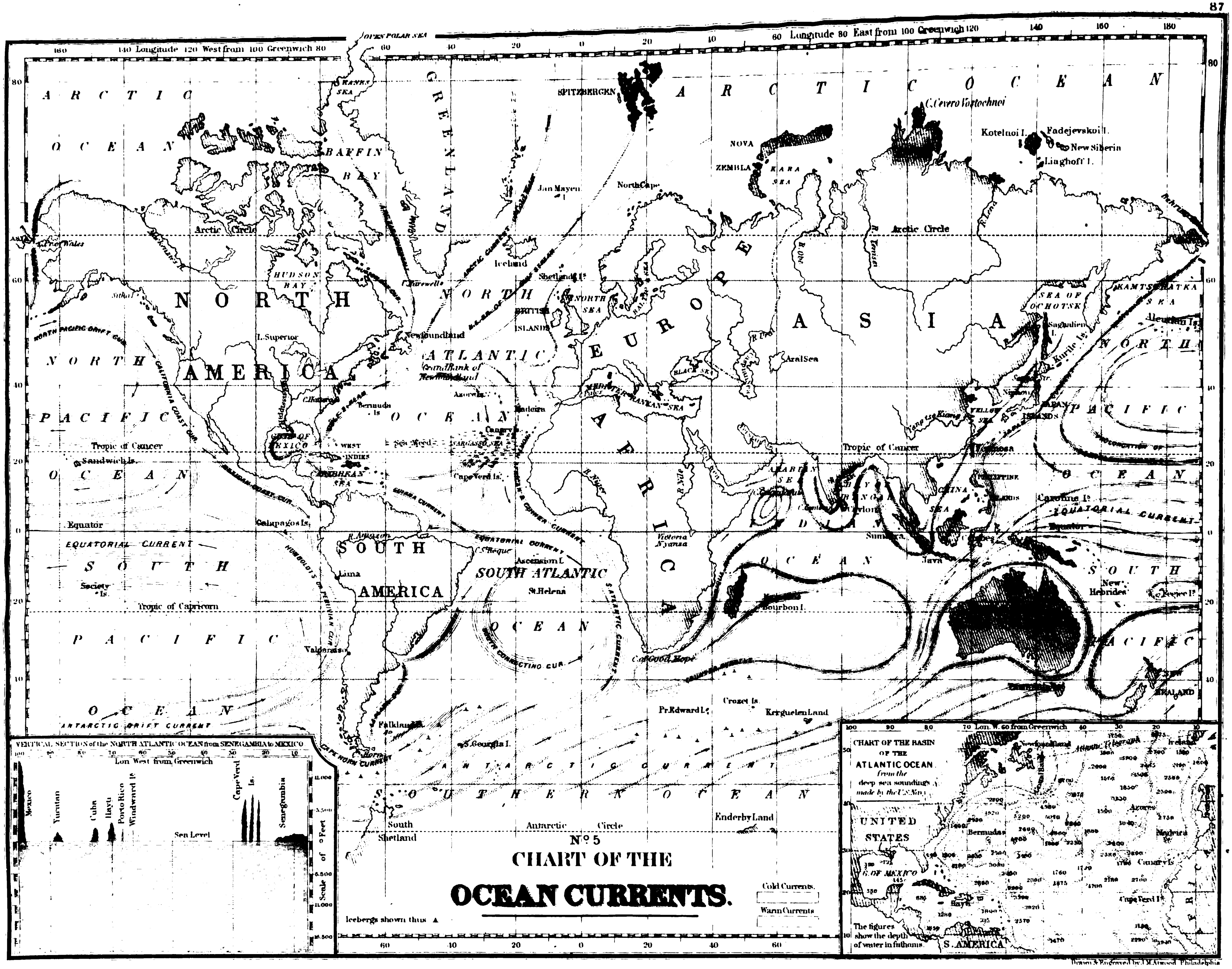
What are waves? Describe their nature.
What is said of their size and velocity?
Describe earthquake-waves.
What do we know respecting the force of waves?

TIDES.

What are tides?
What is meant by high and low, flood and ebb tides?
What is the interval of time between two consecutive high or low tides?
How are tides caused? What are the spring and neap tides?
How are they caused, and how often do they occur?
What is the nature of the tide-wave?
Explain cotidal lines. Why are they curved?
Show from the map, page 80, near what places passes the cotidal line VI, that touches the eastern extremity of New Zealand.
Trace in the same way the cotidal line XII east of Madagascar, and the lines VI, IX, XII, and III in the Atlantic Ocean.
Follow also lines XII and III in the Pacific.
Give an account of the origin, progress, and velocity of the tidal wave.
Show from the map, page 80, the difference in the time of the tide between New Zealand and Tasmania. Between Cape Leeuwin and the Maldive Islands. The Isle of Bourbon and St. Helena. Rio Janeiro and the Cape Verd Islands. Cuba and Cape Farewell. Newfoundland and Iceland. Cape Horn and Lima. Gulf of California and San Francisco. Aleutian and Solomon Isles.
State what is said of the time and height of the tide.
What are derivative tides? Have lakes any tides?

OCEAN-CURRENTS.

What is the third grand movement of the ocean?
How do they originate? How are they classified?
Trace the courses of the great constant currents on the map.
How are the other constant currents caused?
Point out on the map the course of the Arctic current, and of each of its branches.
Trace the Atlantic Equatorial current from its origin throughout its circuit. Where does it divide?
What branch skirts the eastern shore of South America?
With what current does it blend?
Follow on the map the course of the Gulf Stream.
What is its velocity in different parts of its course?
Where is it deep, and where broad? What are its branches? Trace them on the map. What is the Sargasso Sea?
What is said of the temperature of the Gulf Stream as compared with that of the surrounding ocean?
How is Europe affected by its warmth?
Why does either a warm or a cold current, flowing through the ocean, maintain a temperature different from the latter?
What currents flow by the western coast of Africa, and in what direction? Trace them on the map.
Describe and point out on the map the Antarctic Drift current and its branches, and follow their courses.
Describe the Pacific Equatorial current and its branches, and trace their courses on the map.
What ocean-stream does the Japan current resemble?
State the points of resemblance.
Describe the North Pacific Drift current, and trace its course on the map.
How is Northwest America affected by it?
Point out and describe its branches.
Describe the Trade Drift current.
Show where it divides, and trace its branches.
Where is the Cape current?
What is the situation of the counter-current of the Indian Ocean?
Describe it. In what direction does it flow?
Point out on the map the periodical currents which are mentioned, and describe them.
How are local currents caused? Describe the Maelstrom.
What are submarine currents? Which of these is best known?
How is their existence proved by icebergs?



N° 5
CHART OF THE
OCEAN CURRENTS.

SNOW-STORM ON THE PLAINS.

PART FIFTH.

METEOROLOGY.

1. **Meteorology** is a description of the atmosphere and its phenomena, and comprises the following subjects,—viz.: the Atmosphere, Thermal Phenomena, Aqueous Phenomena, Climate, Optical and Luminous Phenomena, Electrical Phenomena.

CHAPTER I.

THE ATMOSPHERE.

2. **General Description.**—The third grand division of the globe is the *Atmosphere*, a vast ocean which envelops the land and sea. It is a constituent part of the earth, revolving with it, and partaking of its general motions.

3. **Constitution.**—The atmosphere is an invisible, elastic, aerial fluid, consisting of dry air and vapor of water. The air is mainly composed of two gases, *nitrogen* and *oxygen*, in the ratio, by volume, of nearly seventy-nine parts of the former to twenty-one of the latter in every one hundred parts of dry air; and with them is mingled a small quantity of carbonic acid gas.

These gases, though differing in density, exist in a state of mixture, and penetrate each other so that they are found in every part of the atmosphere, and always combine substantially in the same relative quantities. This law of the diffusion and union of gases reveals a most benevolent design. If the gases combined like liquids, the heavy and deadly carbonic acid gas would flood the surface of the earth, destroying all animal life; and the same fatal result would occur if the relative proportion of the oxygen and nitrogen were changed. Aqueous vapor is always found in the atmosphere, diffused amid its gaseous atoms, and increasing in quantity with the increase of temperature.

4. **Pressure.**—The atmosphere, like any other material body, presses upon the earth; and the amount of this pressure is measured by the barometer,—an instrument so called from the Greek words *baros*, "weight," and *metron*, "measure." This instrument, which was invented in the seventeenth century by Torricelli, an Italian philosopher, consists of an upright glass tube, more than thirty inches long, with one end closed, the open end being inserted in a reservoir of mercury. A vacuum being formed in the upper end of the tube, a column of mercury is forced upwards into this vacuum by the pressure of the atmosphere, to the height, at the sea-level, of about thirty inches above the mercury in the reservoir.

The weight of this mercurial column, which is about fifteen pounds on the square inch, balances the weight of a column of the atmosphere of the same base; and any fluctuation in the weight of the latter produces a variation in the height of the former,—the mercury falling as the atmosphere becomes lighter, and rising as it grows heavier.

The pressure of the atmosphere varies in different latitudes: it increases somewhat from the equator to the 30th parallel, where it is greatest, then decreases to nearly the 64th parallel, where it is least; after which it increases to the 75th or 76th degree of latitude, where it is the same as at the equator. The pressure of the atmosphere varies also with the altitude above the sea-level, as is proved by the falling of the barometer on lofty mountains and in elevated balloons, the mercurial column sinking about one-tenth of an inch for every eighty-seven feet in altitude. When Messrs. Glaisher and Coxwell of England, in September, 1862, ascended in a balloon, they rose so high that the barometer sank to ten inches, indicating an altitude of five and three-quarter miles.

5. **Density.**—As the atmosphere is elastic, a given volume will occupy less space under increased pressure, and the reverse. On this account, as the lower strata of the atmosphere are pressed upon by the upper, they are more dense than the latter, and the air is found to be more and more rarefied the higher we ascend.

This rarefaction, at lofty altitudes, lessens the intensity of sound, produces lassitude, and renders respiration difficult; sight fails, and blood

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What is the subject of Part Fifth? 1. Define Meteorology. Give its divisions. 2. What is the atmosphere? 3. What its constitution? How do its constituent gases combine? What beneficent law here obtains? What is said of aqueous vapor? 4. How is the pressure of the atmosphere measured? Describe the barometer. What is said of the pressure of the atmosphere as respects latitude and altitude? 5. What is said of the density of the atmosphere?

bursts from the veins. At Lake Sir-i-Kol, 15,600 feet above the sea, Lieutenant Wood found that a musket loaded with blank cartridge gave but a faint sound, a run of fifty yards made the runner gasp for breath, and it took hours of rest to restore his strength. The sight of Mr. Glaisher grew dim in his lofty ascent; and blood flowed from the veins of the eyelids of Dr. Tschudi on the high table-lands of Peru.

6. **Temperature.**—The air, like a solid body, is affected by heat; but the subject of atmospheric temperature is so important as to require a separate discussion, which will be given in the next chapter.

Height.—It is a question with philosophers whether the atmosphere has any definite boundary. Thus much at least is known from observations upon the twilight,—that at the altitude of from forty to fifty miles above the earth it is sufficiently dense to reflect the solar rays. If, however, shooting stars are ignited by the compression of the air, as is supposed, the atmosphere must extend to the height of several hundred miles above the earth.

CHAPTER II.

THERMAL PHENOMENA.

1. THE atmosphere is chiefly warmed in two ways: first, by the direct rays of the sun; secondly, by the heat radiated from the land and sea, which is mainly arrested by the lower strata of the atmosphere. The land radiates heat more rapidly than the water.

2. **Thermometer.**—The fluctuations in temperature are measured by the thermometer,—so called from the Greek words *thermos*, "warm," and *metron*, "measure." The principle and construction of this instrument may be explained as follows.

Take a glass tube with a fine and even bore, open at one end and terminated by a bulb at the other. Partially filling it with mercury, which expands very much by heat and contracts greatly by cold, subject it to the heat of a lamp, until the expanding mercury begins to overflow the top of the tube, previously drawn to a fine point. This point is now melted by a flame, closing the orifice and completely excluding the air. The next step is to graduate the instrument. For this purpose, the tube is immersed in melting ice or snow, when the mercury contracts, gradually sinking until it becomes stationary. The height of the mercury is now marked on the glass. This is the *freezing point.* The instrument is then placed in the vapor of boiling water (the barometer standing at thirty inches), and the mercury, expanding, rises to a certain height, where it remains at rest: this altitude is also marked upon the glass, and is the *boiling point.*

These two points are invariable, indicating, all over the globe, the same amount of heat and cold under the same atmospheric pressure. In Fahrenheit's thermometer, the space between freezing and boiling point is divided into 180 equal parts, called degrees, and thirty-two of these spaces extend below the freezing point to 0, or zero. The freezing point is, therefore, 32°, and the boiling, 212°. For extreme temperatures the scale is graduated to 20°, 40°, and 60° below zero, the degrees being marked thus, — (*minus*). Spirit thermometers are used at very low temperatures, as mercury congeals at forty degrees below zero.

3. **Changes in Temperature.**—The atmosphere is subject to variations in temperature, which arise from numerous causes, some of which are constant in their operation, and others irregular. The two chief permanent causes are changes in latitude and altitude. The rays of the sun falling almost vertically upon the surface of the earth within the tropics, impart to that region more heat than to any other portion of the globe, the temperature gradually decreasing north and south towards either pole, as the sunbeams fall at a less and less angle upon the earth's surface. The temperature of the air at the sea-level decreases, therefore, with the increase of latitude, as is found by observations. At Maracaybo, in 11° 19′ north latitude, the mean annual temperature is 84° Fah.; while in 78° 37′ north latitude it was found by Dr. Kane to be only —3° .2 Fah., the lowest yet known. This general rule has, however, its exceptions, arising from local causes. The mean annual temperature of Massuah, in 15° 36′ north latitude, is 87° Fah., and is the highest hitherto observed.

As already stated, the heat which is radiated from the earth is chiefly arrested by the lower strata of the atmosphere. As a consequence of this, the temperature of the atmosphere decreases with the altitude. From the observations made by aeronauts, and by travellers who have scaled the highest mountains, the average loss of heat is found to be about 3° Fah. for every 1000 feet of elevation. In regions where the cold is intense, this law is partially reversed.

4. **Mean Temperatures.**—*The mean daily temperature* of any place is found by taking the average of the thermometrical observations made at stated hours during the day; and the *annual mean temperature* is the average of the daily mean temperatures. The annual mean temperature of any place may be regarded as invariable; for the more perfect the system of daily observations, the more nearly do the mean annual temperatures of different years coincide with each other.

In Toronto, where hourly observations were made for two consecutive years, their annual means did not differ more than *one-tenth* of a degree Fah.

OF WINDS.

5. Wind is air in motion, and may arise from any cause which disturbs the repose of the atmosphere; but it is chiefly produced by changes in the temperature of the latter. When a body of air grows warmer than that which surrounds it, it expands, becomes lighter, and rises, while the colder and denser air below flows in to fill up the void it has created. This is proved by the simple experiment of Franklin, which is made as follows: a door being opened that communicates between a warm and a cold room, the flame of a candle at the top of the door is bent towards the cold room, while at the bottom the direction of the flame is reversed, thus establishing a circuit.

On account of the variation of temperature in different latitudes, phenomena of this kind are constantly occurring throughout the world. For if two neighboring regions are unequally heated, an upper wind flows from the hotter to the cooler region, while the cold and heavy air of the latter produces a lower surface-wind flowing towards the warmer region. The difference in temperature between the higher and lower latitudes thus produces a constant change of air between them. The atmosphere, like the ocean, is ever in motion, and is traversed in all directions and at all heights by currents of air

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What effects are produced by the rarity of the air of high elevations? Give instances. 6. What is said respecting the temperature of the atmosphere? What of its height?

What is the subject of Chapter II.? 1. In what two ways is the atmosphere warmed? How are the changes of temperature measured? 2. Explain the construction of the thermometer. 3. What is said respecting the causes of the changes in temperature? What are the two chief permanent influences? Give an account of the variations of temperature in latitude, and also those of altitude. What is the law of variation in altitude? 4. What is meant by the mean daily temperature and the mean annual temperature? How are they obtained? What is said as to the constancy of the mean yearly temperature? 5. What is wind? How is it caused? What is the chief cause? Explain Franklin's experiment, and apply the reasoning. What is the condition of the atmosphere in respect to repose? What is said of its currents?

moving with varying velocity. Some of these are changeable in their direction, and others constant.

The velocity of the surface-winds ranges from the slightest motion to the speed of the hurricane, which is sometimes about one hundred miles an hour. The velocity of the upper currents is also very great; for the balloon of the aeronaut Elliot was carried thirty miles in twenty minutes.

6. **Upper Winds.**—The higher winds of the atmosphere move frequently in contrary directions. The aeronaut Wise, in his ascent from Portsmouth, Ohio, in 1852, beheld below him, from the height of two thousand feet, two thunder-storms at the same time, one of which came from the northwest, the other from the southwest; and it is by no means uncommon, when several balloons ascend together, to see them borne away in different directions at different heights. The same fact is attested by the drifting of volcanic ashes; for in the awful eruption of Sumbawa, ashes were carried to Banda, eight hundred miles to the east, by the sweep of the higher winds, in a direction contrary to that of the monsoon.

7. **Winds classified.**—Winds are divided, in regard to their duration, into *Constant*, *Periodical*, and *Variable*. The Trade-winds constitute, for the most part, the first class; the Monsoons, the land and sea breezes, Etesian winds, and Northers of Mexico, the second,—all occurring within or near the tropics. Variable winds include those not comprised within the other classes, and prevail beyond the tropics.

Constant Winds.—Trade-Wind.—Within the torrid zone a vast current of air is constantly sweeping westerly, which maintains its rate and direction nearly unchanged throughout the year. By this wind Magellan was first wafted across the Pacific; and two centuries ago, in the palmy days of the Spanish Empire, her rich gold-ships were thus borne peacefully along from the shores of the New World to the Philippine Isles.

The origin of this wind is thus explained. The atmosphere in the torrid zone, being intensely heated, is expanded, and its density lessened: in this condition, being pressed upon by the colder and denser masses of air from the other zones, the vast volume of hot air rises, flowing off in two upper currents towards either pole, while two cold lower currents set in towards the equator from the north and south.

If the atmosphere were influenced by no other cause, a north wind would constantly blow towards the equator, in the Northern Hemisphere, and a south wind in the Southern: their respective directions are, however, modified by the rotation of the earth. The atmosphere moves easterly with the same speed of rotation as the solid globe. This speed is almost nothing near the poles, but increases as we advance towards the equator, where it is greatest.

A mass of air in the Northern Hemisphere, moving towards the south, is constantly arriving at regions which have a greater easterly velocity than itself, and, in consequence of friction and of its own inertia, it does not at once gain this greater velocity, but lags behind, and acquires a relative westerly motion. The lower current in the Northern Hemisphere is, therefore, influenced by two forces, one of which causes it to move from north to south, and the other from east to west, at the same time; and the result of their combined action is a northeasterly wind. In the Southern Hemisphere the same forces, as will be readily seen, give rise to a southeasterly wind.

In the Atlantic, the northeast trade-winds prevail between the 30th and 8th degrees of north latitude, while the southeast trade is comprised between the 3d degree of north latitude and the 28th of south latitude. In the Pacific the former ranges from the 25th to the 2d degree of north latitude; and the latter probably extends from the 10th to the 21st of south latitude.

Within these parallels the position of the trades varies, however, with the apparent course of the sun, their limits moving northward in summer and southward in winter. This vast current, thus sweeping over nearly the whole breadth of the torrid zone, advances westerly, blowing over sea and land, around the globe, at the rate of from ten to twenty miles an hour. The continents retard its progress. Africa checks the trades of the Indian Ocean, South America those of the Atlantic; while Australia impedes those of the Pacific.

As the land is more intensely heated than the ocean, modifications in the direction of the trades arise from this cause; for, the air being more rarefied over the land than above the sea, the atmosphere moves landward, and the course of the trade-wind is in many instances thus deflected. Near the continent of Africa the trade-winds are not felt within one hundred miles of the shore, and within this tract westerly winds prevail, owing to the great rarefaction of the air over the desert.

8. **Zones of Calms.**—As the northeast and southeast trades approach each other, and reach the zone of highest temperature, their strength diminishes, and is further weakened by the vast uprising column of hot air in this intensely heated clime. The result is that a zone of *calms*, or *variables*, exists, whose mean position is between about the 3d and 8th degrees of north latitude. Within this region the atmosphere is for the most part in a dead repose, which is broken up at intervals by fierce and sudden gusts, giving rise to terrific storms of thunder and lightning, attended by torrents of rain. The belt of equatorial calms is north of the equator: this is owing to the fact that there is more land in the Northern than in the Southern Hemisphere and that the land is more intensely heated than the water. Moreover, the great equatorial ocean-currents carry an immense amount of heat towards the north.

THUNDER-STORM.

According to Maury, the zone of equatorial calms in July and August is found between the 7th and 12th degrees of north latitude, in

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6. State what is said of the direction of the upper winds. Give the proofs. 7. How are winds classified? Name the winds that constitute the several classes, and tell where they occur. Describe the Trade-wind, and how it originates. Within what parallels do the trades prevail? Do their limits fluctuate? If so, why? What is the breadth of the trades? What is the effect of masses of land upon the velocity and direction of the trades? Give instances. 8. How is the equatorial belt of calms caused? Describe it. What is said of its limits?

March and April between the 5th degree of south latitude and the 2d degree of north latitude. These limits thus annually shift their positions in latitude about eight hundred miles.

Near the tropics are two other calm-belts, termed respectively the Calms of Cancer and Capricorn, caused by the equatorial upper currents descending and meeting the polar winds. Their southern limits are near the two tropics, and their respective breadths are from 10° to 12°. The Calms of Cancer have been termed the Horse Latitudes by seamen, from the fact that when cargoes of horses were formerly exported from New England to the West Indies, and ships were here becalmed, a part of the cargo was frequently thrown overboard to save water and fodder for the remaining animals.

9. **The Upper and Lower Westerly Winds.**—The ascent of the heated air from the torrid zone gives rise, for reasons already unfolded, to a constant upper wind, blowing in a direction contrary to the trades. An upper southwesterly wind, therefore, prevails within the northern tropic, and a northwesterly within the southern. These upper winds, advancing beyond the two tropics, become cooled, and, descending towards the earth, change in part to surface-winds; and, though subject to many conflicting influences, so powerful is their effect that the predominance of westerly winds in the Northern and Southern Hemispheres is fully established.

In France, England, Germany, Denmark, and Sweden, the prevailing direction of the wind is from a point varying from south 50° west to south 88° west; while it appears from the elaborate researches of Professor Coffin that its general direction in the United States is 87¾° west of south. The observations of such aeronauts as Green and Wise attest the existence of a constant upper westerly wind in the temperate climes of the Northern Hemisphere. The existence of northwesterly winds in the Southern Hemisphere is also abundantly proved both by the observation of Lieutenant Maury and the record of the United States Exploring Expedition under command of Captain Wilkes.

10. **Periodical Winds.—Monsoons.**—Within and near the tropics periodical winds prevail, termed monsoons, from the Malay word *mousim*, signifying "season." They blow for nearly six months in one direction; then follows a short interval of dead calms, variable winds, and storms; after which they blow in a contrary direction for nearly the rest of the year.

From October to April the northwest monsoon prevails in the Southern Hemisphere, and the northeast in the Northern. From April to October the southwest monsoon occurs north of the equator, and the southeast in the Southern Hemisphere. The northwest and southwest monsoons come later, according as the countries where they occur are farther removed from the equator.

The northeast and southeast monsoons are portions of the trade-winds, and the southwest and northwest monsoons are deflections of the same, caused by the proximity of highly-heated regions during the summer. "Thus," says Maury, "the African monsoons of the Atlantic, those of the Gulf of Mexico, and the Central American monsoons of the Pacific, are for the most part formed of the northeast trade-winds which are turned back to restore the equilibrium which the overheated plains of Africa, Utah, Texas, and New Mexico have disturbed."

The same phenomenon is observed on the Eastern Continent. When the sun advances towards the northern tropic, the zone of greatest heat advances with it, and the peninsula of India, with the plains of Central Asia, becomes intensely heated. Under these circumstances, not only is the northeastern trade arrested, but the cooler air from the equatorial sea flows towards the continent. Southwesterly winds thus arise, which prevail along the Asiatic coast as far as the Arabian Gulf, till the time of the autumnal equinox.

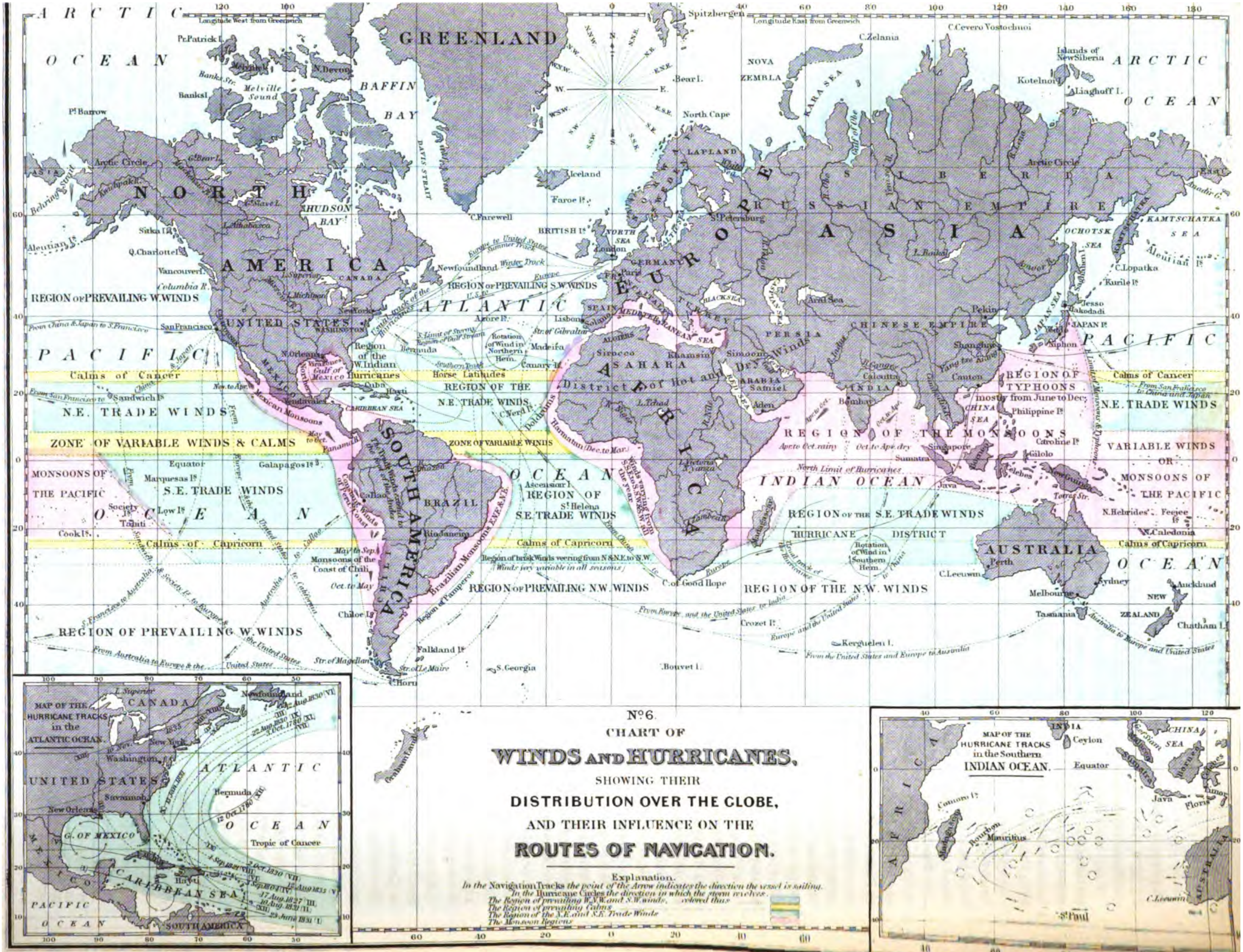
MONSOON.

When the sun advances towards the southern tropic, similar changes occur: the southeast monsoon is checked, its current reversed, and northwesterly gales sweep over the heated plains of South Africa and Australia. Violent storms occur at the shifting of the monsoons. Local causes modify the direction of these winds: along the Mexican coast the northwest monsoon blows from November to April, and the southwest from May to October, owing to the configuration of the coast.

11. **Land and Sea Breezes.**—On the islands and sea-coasts of the tropics, a breeze sets in from the sea towards the land a few hours after sunrise, steadily increasing till about three o'clock, the hottest part of the day, after which it gradually dies away until sunset, when there is a perfect calm. Soon after, a breeze from the land arises, and blows seaward till morning, when it fails, and the sea-breeze recommences.

Although these breezes are most marked in the tropical climes, they occur along the sea-coasts in nearly all latitudes, being perceptible on the shores of Norway and Greenland. They originate as follows. The land in the regions where they occur is hotter than the water during the day, and cooler during the night; for in the tropics, where the sea-breeze is most powerfully felt, the air over the land attains a temperature of 120° Fah., while that over the sea seldom exceeds 80° Fah. The hot air of the land, thus becoming lighter, ascends, and the cooler air of the ocean flows in to supply its place. As the sun sinks, the land loses its heat rapidly by radiation, the air above it sinking correspondingly in temperature, until it is colder than the air above the sea; and when this occurs, the land-breeze commences. This difference increases through the night, and with it the strength of the land-breeze. At sunrise, when the land-breeze blows strongest, this is greatest, the sea being from 15° to 20° Fah. warmer than the land.

Where are the Calms of Cancer and Capricorn? How are they caused, and what is said of their breadth and limits? Why are the Calms of Cancer called the Horse Latitudes? 9. Describe the upper and lower westerly winds, and explain how they originate. Give proofs of the theory. 10. What are monsoons? Describe them. Show how they originate. What happens at the shifting of the monsoons? Are they modified in direction by local causes? 11. Describe the land and sea breezes, and show how they originate. Do such winds occur near large lakes?


ARCTIC OCEAN
GREENLAND
BAFFIN BAY
DAVIS STRAIT
HUDSON BAY
NORTH AMERICA
CANADA
UNITED STATES
MEXICO
REGION OF PREVAILING W. WINDS
PACIFIC OCEAN
Calms of Cancer
N.E. TRADE WINDS
ZONE OF VARIABLE WINDS & CALMS
MONSOONS OF THE PACIFIC
S.E. TRADE WINDS
Calms of Capricorn
REGION OF PREVAILING W. WINDS
Region of the W. Indian Hurricanes
Mexican Monsoons
SOUTH AMERICA
BRAZIL
Brazilian Monsoons E.N.E. & N.E.
Region of Pamperos
ATLANTIC OCEAN
REGION OF PREVAILING S.W. WINDS
Horse Latitudes
REGION OF THE N.E. TRADE WINDS
ZONE OF VARIABLE WINDS
REGION OF S.E. TRADE WINDS
REGION OF PREVAILING N.W. WINDS
EUROPE
RUSSIAN EMPIRE
AFRICA
SAHARA
District of Hot and Dry Winds
Harmattan (Dec. to Mar.)
Winds varying from S.S.E. to S.S.W. & S.W. all the year
ASIA
CHINESE EMPIRE
PERSIA
ARABIA
INDIA
REGION OF THE MONSOONS
REGION OF TYPHOONS mostly from June to Dec.
INDIAN OCEAN
North Limit of Hurricanes
REGION OF THE S.E. TRADE WINDS
HURRICANE DISTRICT
REGION OF THE N.W. WINDS
AUSTRALIA
NEW ZEALAND
VARIABLE WINDS OR MONSOONS OF THE PACIFIC
Longitude West from Greenwich
Longitude East from Greenwich
MAP OF THE HURRICANE TRACKS in the ATLANTIC OCEAN
MAP OF THE HURRICANE TRACKS in the Southern INDIAN OCEAN.

No. 6.

CHART OF

WINDS AND HURRICANES,

SHOWING THEIR

DISTRIBUTION OVER THE GLOBE,

AND THEIR INFLUENCE ON THE

ROUTES OF NAVIGATION.

Explanation.

In the Navigation Tracks *the point of the Arrow indicates the direction the vessel is sailing.*

In the Hurricane Circles *the direction in which the storm revolves.*

The Region of prevailing W.N.W. and S.W. winds, coloured thus 🟦

The Region of prevailing Calms 🟨

The Region of the N.E. and S.E. Trade Winds 🟦

The Monsoon Regions 🟪

For the same reason, around extensive lakes there is a breeze from the water in the morning and from the land during the night.

12. **Etesian Winds.**—This name, derived from the Greek word *etos*, a "year," was given by the ancients to the periodical winds which blow from the northeast, for above six weeks during the summer, over the Mediterranean and its adjacent countries. Throughout this season the desert of Africa becomes intensely heated, while the waves of the Mediterranean possess a far lower temperature. Under these circumstances, a cool current of air sets in from a northern quarter, producing the winds in question. In winter, when the desert sinks rapidly in temperature, from its powerful radiation, it becomes colder than the sea, and in Egypt a cold south wind is then experienced, but less strong than the summer winds.

13. **Northers.**—These are cold and boisterous winds, which blow over the plains of Mexico and Texas from October to March, seldom continuing for more than four or five days at a time. Their severity is greatest during the months of December and January.

14. **Variable Winds.**—In the extra-tropical regions the constant winds of the globe become feeble, and a variety of secondary influences, such as the unequal distribution of land and water, the nature of the soil, the conformation of the surface, and many other circumstances, check and disturb their flow, and give rise to variable winds. In the Northern Hemisphere beyond the tropics, the constant northeast polar and the southwest equatorial winds are thus in perpetual conflict with local influences, and variable winds prevail. In the southern extra-tropical climes the prevalent northwest equatorial and the southeast polar winds meet with the same influences, though in a less degree, rendering the winds fickle and changeable.

According to Professor Coffin, three systems or circuits of winds prevail in each hemisphere between the equator and the poles. Thus, in the Northern Hemisphere the first, or equatorial, is found between the equator and latitude 30°; the second reaches from latitude 30° to latitude 60°; and the third, or polar, extends from latitude 60° to latitude 90°. In all these systems in the Northern Hemisphere the upper winds are southwesterly, and the lower northeasterly. At the limits of these systems, where the opposite currents blend, calms are supposed to occur, like those of Capricorn and Cancer.

15. **Nature of Winds.**—The condition of winds in respect to temperature and moisture depends upon the direction whence they blow, and the nature of the surface over which they pass. Winds blowing from the polar regions over the sea are cold and moist, and over continents and deserts, cold and dry. Breezes from the equatorial regions, sweeping over the sea, are warm and moist; those over the land, warm and dry. Certain winds possess in these respects such marked peculiarities as to deserve particular notice.

16. **Hot Winds.—The Simoom.**—Over the arid wastes of Asia and the Sahara of Africa a hot wind at times prevails, known by the name of the Simoom,—from the Arabic word *Samma*, meaning at once both "hot" and "poisonous." Its pestilential character is, however, a mere fiction, as it is simply an intensely hot and dry wind.

Mr. J. S. Buckingham, who was exposed for eighteen hours to this fearful blast, thus describes it. "The chief danger to the caravan is the Simoom. It comes like the heated air from a fiery furnace, producing fainting and lassitude, and soon, increasing in violence, raises the sand in clouds, penetrating the eyes, nose, and mouth. The camels are arranged in line, and beside them the travellers prostrate themselves for shelter. Soon the flying sand drifts as high as the camels' backs, and a new line must be formed, amid the thick darkness produced by the hot and blinding sand. Again and again must this be done,—and frequently all in vain. A caravan of twenty thousand pilgrims, returning from Mecca, were once overtaken by the Simoom, and only eighteen escaped to tell the tale."

17. **Khamsin.**—From the beginning of April, a hot south wind, called the Khamsin, blows in Egypt, at intervals for the space of fifty days, seldom lasting more than three days at a time. It is similar to the Simoom in its nature; but its effects are not so injurious. It rapidly absorbs moisture, and the furniture of the houses cracks and splits beneath its influence.

18. **Harmattan.**—The Harmattan is a periodical easterly wind which is found in Africa, extending over Senegambia and Guinea for a distance by the coast of more than 2000 miles. It prevails from December to March, occurring three or four times during its season, and continues from one to fifteen days at each period. It is an extremely hot and dry wind; and during its prevalence a haze so dense obscures the sky that the sun is visible only a short time at midday, glowing like a ball of fire.

19. **Sirocco.**—This is a southeast wind, which occurs during the summer in Italy and Sicily, but most violently in the vicinity of Naples and Palermo. It comes from the desert over the Mediterranean, is hot and humid, and is exceedingly oppressive and debilitating.

The *Solano*, or Levanter of Gibraltar, is also a hot southeast wind, which comes to the strait loaded with the impalpable dust of the desert.

20. **Cold Winds.—Puna Winds.**—The high table-lands of Peru, known by the name of the Puna, are subject for four months of the year to intensely cold winds, which descend from the icy peaks of the Cordilleras. They are extremely dry, and so rapidly absorb the moisture from dead animals as to prevent putrefaction.

21. **Pamperos.**—These are cold northwest winds, which, rushing down from the snowy peaks of the Andes, sweep over the dry pampas of South America to the Atlantic. Such clouds of dust are borne onward by these winds, and so great is their violence, that a darkness like night sometimes occurs at Buenos Ayres, and the La Plata rolls in billows like a sea.

22. **Mistral, Bora, and Black Wind.**—These winds prevail in the south of Europe. The Mistral is a cold northwest wind which descends from the mountains of Central France and blows with violence over its southeastern regions. The Bora is a cold northeast wind which sweeps down with fury from the Alpine heights over Istria and Dalmatia. The Black Wind, or *Vent de bise*, is a cold, piercing current from the Alps and the mountains of Auvergne, which in its course follows for the most part the valley of the Rhone.

23. **Cyclones.**—This term, derived from the Greek word *kuklos*, a "circle" or "whirl," is now given by meteorologists to those tremendous rotary tempests which, under the various names of Hurricanes, Storms, and Typhoons, prevail for the most part within and near the tropics, near the equatorial limits of the trade-winds, but extend likewise into the higher latitudes.

Within the torrid zone they rage with the greatest fury, accompanied at times with terrific thunder and lightning: forests are levelled, and buildings of the firmest structure destroyed in a moment; while the sea, rising in immense waves, sweeps over the low shores, destroying the inhabitants by thousands, and lining the coasts with wrecks. In 1839 a hurricane fell upon Coringa, on the eastern coast of India.

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12. Describe the Etesian winds and their cause. 13. Describe the Northers. 14. Where do variable winds prevail, and why? What are Prof. Coffin's views respecting the systems of winds? 15. What is said of the nature of winds? 16, 17. Describe the Simoon and Khamsin. 18, 19. Describe the Harmattan, Sirocco, and Solano. 20. Describe the Puna wind. 21, 22. Describe the Pamperos, Mistral, Bora, and Black Wind. 23. What are Cyclones? Describe their effects.

The sea swept over it in a mighty wave; all the houses but three or four were destroyed, twenty thousand persons perished, and a sloop of more than fifty tons' burden was carried four miles inland.

The phenomena of hurricanes have been thoroughly investigated in nearly every quarter of the globe, by men of the highest ability and science, such as Redfield, Reid, Thom, and Piddington; and the conclusions to which these able investigators have arrived in respect to the laws of tropical storms are as follows:—

1st. That the wind revolves around an axis, inclined or vertical, while the body of the storm has at the same time a progressive motion.

2d. That in the Northern Hemisphere the cyclone rotates in a direction contrary to the apparent motion of the sun, and in the Southern Hemisphere in the same direction as the sun.

3d. That in the Atlantic the cyclones begin near the West India Isles, between the parallels of 10° and 20° north latitude; that their course is at first from southeast to northwest, when, having passed the northern tropic, they proceed from southwest to northeast; and that they occur most frequently between May and October.

In the Indian Ocean their course is reversed, and they proceed at first from northeast to southwest, when, having crossed the southern tropic, their direction is changed from northwest to southeast. They originate near the isle of Mauritius, and prevail between November and May.

The typhoons of the Chinese Sea occur between June and December. The great hurricanes of the Atlantic and Indian Oceans range in diameter from fifty to nearly one thousand miles, and move with varying velocities along their paths. In the Atlantic their progressive speed is from seventeen to forty miles an hour; in the Chinese Sea they have an average speed of from seven to twenty-four; in the Bay of Bengal, from three to fifteen; and in the South Indian Ocean, from one and a half to three miles per hour.

On the theory that hurricanes are revolving storms, it must necessarily be the case that the wind will blow in different directions in different parts of the storm, and that the pressure of the atmosphere within its circuit will decrease from the circumference to the centre, while its velocity increases, and that in the very centre of the storm there will be a vortex, where the air is in repose. These inferences are fully established by facts.

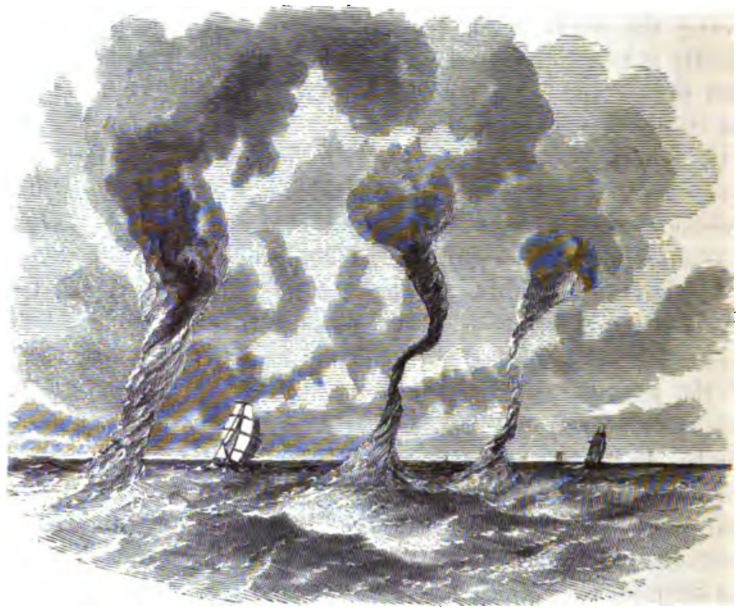
Captain Newby, in describing the Antigua hurricane of 1837, remarks, "On the 2d of August, at 3 P.M. the wind blew violently from north-northwest, at 5 P.M. it increased to a gale, at 7 P.M. it was an awful hurricane; then succeeded a calm for the space of ten minutes, when, with a most tremendous screech, the wind recommenced from the south and southwest; by two o'clock in the morning the gale abated, and the barometer rose an inch." Meteorologists are by no means agreed as to the cause of cyclones; and but very little light has been thrown by them upon this subject.

24. **Tornados.**—Tornados are whirlwinds of limited extent and duration, though not inferior to hurricanes in power. They vary in diameter from a few feet to several hundred yards, and continue but a few seconds.

In May, 1855, a tremendous whirlwind passed over Cook county, in Illinois. The trunks of trees of the largest dimensions were twisted off, and a heavy frame house was carried up, with nine persons, into the air: the building was torn to pieces, three persons were killed, and the rest severely injured. During the same year, a tornado that swept over Cass county, in Missouri, moved from their places large rocks of more than a ton weight, which were imbedded in the earth.

These terrific tempests are often attended by floods of rain, extraordinary electric phenomena, and destructive torrents of hail.

The whirlwind is frequently accompanied by a funnel-shaped cloud, having its point towards the earth, as was the case in the Illinois hurricane. When it passes over a body of water, this point frequently extends lower and lower, while the water beneath is violently whirled up in a column of spray. As the cloud descends, it unites with this column, and a water-spout is formed, which appears like an immense tube swayed by the winds, and has both a progressive and a rotary motion. The common belief that water is drawn up into the clouds by these whirlwinds is erroneous; for the water which falls from them is fresh, and is produced in the same way as rain.



WATER-SPOUTS.

When whirlwinds sweep over the deserts, the light sand is frequently tossed aloft, forming sand-columns of immense height. Eleven were seen at one time by Bruce in Africa, moving with great swiftness. The largest did not exceed ten feet in diameter; but they all rose to a great height.

Whirlwinds are supposed to originate from the conflict of opposing winds, and also from the action of a strong breeze upon a body of air in repose, in the same way as eddies are formed in water.

An uprising current caused by a conflagration gives rise to inflowing currents of air, and sometimes produces whirlwinds. This phenomenon occurred during a terrible fire at Prome, in Birmah, in 1862, which destroyed 4800 houses. Dr. Kincaid, who was present, remarks, "So intense was the heat that fearful whirlwinds were produced, which stripped the roofs from the buildings, and, lifting the fiery masses to a great height, scattered them in all directions. The noise of these whirlwinds was like distant thunder."

25. **Navigation.**—An accurate knowledge of the phenomena of winds, ocean-currents, and tides is of great importance to the world, by facilitating the operations of commerce and increasing its security.

At no period, since Vasco da Gama opened the ocean-road to India and Columbus gave a new continent to Europe, has this

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Mention some of the men of science who have investigated the phenomena of hurricanes. What are the results of their researches? What is said of the extent and speed of hurricanes? What must be true on the rotary theory of hurricanes? Do facts prove the theory? What is the cause of cyclones? 24. Describe tornados and water-spouts. What error is prevalent in regard to the latter? What is said respecting sand-columns? How are whirlwinds caused? What is the effect of extensive conflagrations? Give the example. 25. What practical benefit results from the knowledge of the phenomena of winds, ocean-currents, and tides? What is said of the demands of the present century in this respect?

knowledge been so imperatively demanded as within the present century. For during this time commerce has been rapidly developed, and its energy and enterprise aroused to full activity by the inventions of science and the discovery of the rich gold-fields of the globe. And these demands have not been left unanswered.

In our own country, Lieutenant Maury, from the numerous log-books of the commercial and naval marine, has constructed a series of wind and current charts, accompanied with sailing-directions, which are of great service to mariners, and new routes have been discovered, by which the voyages of vessels have been very much shortened. "Voyages," says Lieutenant Maury, "from the United States to Australia have been reduced from 127 to 92 days, and between England and Australia from 111 to 90 days. When I first took up the discussion of this subject, the average passage from the Atlantic ports of the United States, as well as from the ports of Europe, to California, was 180 days. Now the average passage of 300 vessels is, by the new route, 130 days." Voyages have even been made in 92, 91, and 89½ days. The improved construction of vessels has, doubtless, had its influence in quickening voyages, but not to such an extent as to detract from the value of the labors of Lieutenant Maury.

In England, extensive researches have been made, and no exertions spared by the government, to improve navigation and benefit commerce; and the sailing-directions of the Admiralty are of inestimable service to seamen.

26. **General Routes.**—A short description of the present great routes of navigation may be of use, as showing their connection with the winds and currents.

From the United States to Europe.—In the Atlantic Ocean the navigation-tracks are greatly influenced by the Gulf Stream, the prevalent southwest winds, and the northeast trades. In voyages from the United States to Europe, the southwesterly winds are fair for the mariner, and if he takes advantage of the Gulf Stream, his speed is accelerated. On his return he has the choice of two tracks, a northward and a southward. By taking the latter, he runs down into the region of the northeast trades, and then, by their aid and that of the westerly winds north of their limit, he can gain the ports of the United States.

In the former route, he sails northward of the Gulf Stream, avoiding its adverse currents, and, passing the banks of Newfoundland, strikes the Arctic current, which facilitates his voyage. The limits of the Gulf Stream change with the seasons. In March its northern edge reaches its extreme southern limit, and in September its utmost northern boundary. On this account, the return-track in the summer makes a greater bend to the north than in the winter.

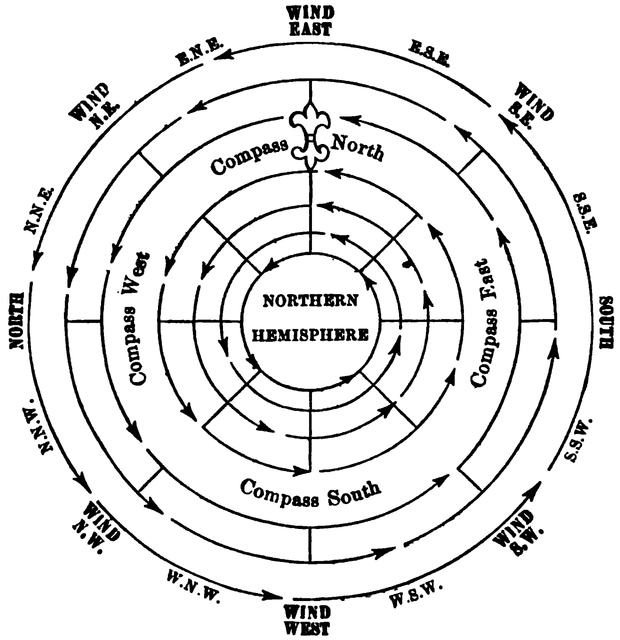
This route is the great ocean-road for packets and steamers; and the breadth of the track pursued by the Cunard and other steamers is about 300 miles. The effect of the adverse winds and currents is so great that, on an average, the length of the outward passage from New York to Liverpool, by a sailing-packet, is twenty-three days, while the return-voyage occupies forty days.

27. *Routes from the United States and Europe to Australia, India, and China.*—Off Cape St. Roque, in Brazil, says Maury, the tracks of all vessels bound out of the North Atlantic Ocean into the Southern Hemisphere fall in with each other. Here the tracks of vessels both from Europe and America come together, whether their destination be around either Cape Horn or the Cape of Good Hope. After passing the equator, vessels bound to Australia take advantage of the southeast trade-wind, and run down to the southern calms; then, steering south till they pass this region, they encounter the prevalent strong westerly winds, which bear them rapidly onward to their destination, aided part of the way by the flow of the South Connecting current. The best way, according to Maury, for vessels bound to Australia from Europe and the Atlantic ports, is to double the Cape of Good Hope and return by Cape Horn,—for the reason that the prevailing winds beyond the tropics are from the northwest, and are, therefore, fair winds for both the outward and homeward voyage.

East of the Cape of Good Hope, the great Australian route branches off to the ports of India and China, by several tracks, dependent upon the monsoons, the more westerly routes being taken during the southwest monsoons.

28. *Routes from the United States and Europe to California and the Northwest coast.*—From the United States, mariners bear away to the common track off Cape St. Roque, called the "Fair Way," crossing the parallel of 30° at about 43° west longitude, and the equator at 31° west longitude. From Europe the same point is sought, the parallel of 30° being crossed at 19° west longitude. In the "Fair Way" the vessels for America and Europe fall in with each other, and the route is the same for the rest of their voyage. Speeding southward, they keep well off the coast of South America, and, passing within the Falkland Islands, double Cape Horn, by sailing through the Strait of Le Maire. Making their way westward as fast as possible, the California fleet enters the southeast-trade regions east of the meridian of 118° west longitude, and, with these favoring breezes, crossing the equator between 105° and 120° west longitude, bears up to San Francisco, on the Northwest coast.

29. *Route from California to China.*—In sailing from California to China, vessels stand to the southwest for the northeast trades, which bear them on favorably to their destination, aided by the great Equatorial current setting westward. On the return-voyage the mariner steers northerly, till within the parallels of 35° and 45° north latitude, where he finds strong westerly winds, which waft him swiftly to the American shores.



STORM CARD, NORTHERN HEMISPHERE.

30. **Storm Charts.**—The researches of Redfield, Reid, Pidding-

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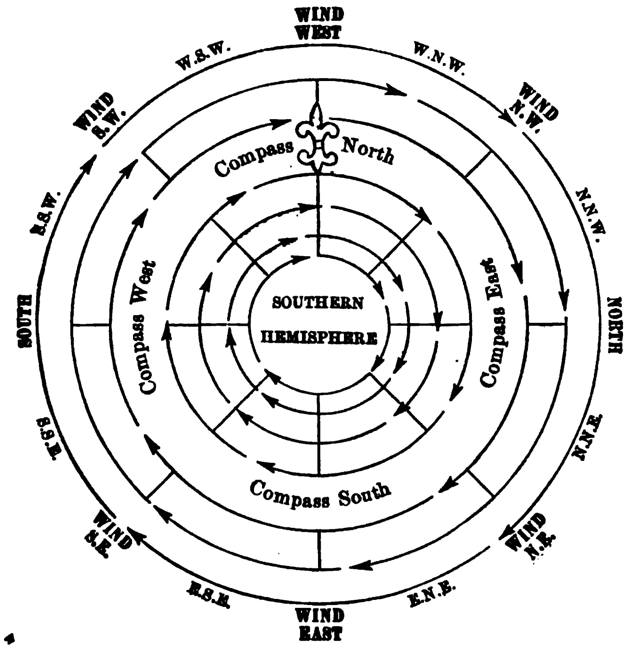
Mention what Maury has done, and state to what extent voyages have been shortened. What has been done for the interest of navigation and commerce in England? 26. Describe the present routes from the United States to Europe.

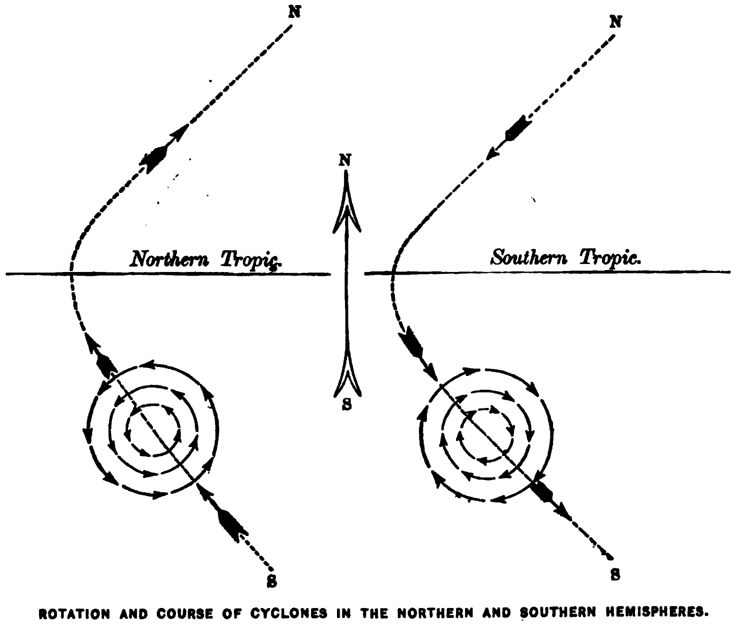
27, 28. Describe the routes from Europe and the United States to Australia, India, and China, and also those from the United States and Europe to California and the Northwest coast. 29. Describe the route from California to China.

ton, and others, upon the nature of cyclones, have enabled them to lay down rules for the guidance of mariners when overtaken by these appalling storms. These rules are based upon the theory that cyclones have both a progressive and a rotary motion; and their observance has greatly contributed to the safety of vessels.

Mr. Piddington, of Calcutta, in his "Sailor's Horn-Book," has prepared, for the aid of seamen, storm cards, which represent a hurricane, the wind moving round in a circle. They are used as follows. When the seaman finds that he is within a cyclone, he marks upon his sea-chart his latitude and longitude, and, placing upon it that card which belongs to the hemisphere he is in, with the wind's place over the ship's place, he sees at a glance on which side of him the centre of the hurricane lies, and in what direction the storm is moving.



STORM CARD, SOUTHERN HEMISPHERE.



ROTATION AND COURSE OF CYCLONES IN THE NORTHERN AND SOUTHERN HEMISPHERES.

Thus, in the Northern Hemisphere, within the tropics, if the wind is northeast, the centre of the hurricane lies to the southeast of the ship, and the body of the storm is moving to the northwest. The mariner, therefore, will bear away to the southwest and escape the storm: a course east of south would bring him into the heart of it. In the Southern Hemisphere, beyond the tropics, a northwest wind shows that the centre of the storm lies to the southwest of the ship, and, as the storm is moving to the southeast, the course which insured safety in the former case would bring destruction in this.

The preceding figures represent the tracks and rotation of cyclones in the Northern and Southern Hemispheres. By supposing the centres of the storm cards to be placed upon these tracks, and to be moved along them in the direction in which the cyclone advances, with the compass pointing north, the preceding statements will be readily understood, and the use of the storm cards clearly seen.

31. **United States Coast Survey.**—In 1832, Congress authorized the survey of the entire coast of the United States; and the work is still in progress. Extensive researches have already been made, and numerous charts constructed, which have conferred great benefits upon commerce.

32. **Advantages of the Winds.**—By their aid the rich products of different climes are interchanged, mankind are bound together by social and commercial ties, and religion and civilization are extended to the remotest regions of the earth.

Health is borne upon the breezes. An atmosphere without circulation would be vitiated by the exhalations from decaying animal and vegetable matter; but, the winds breaking up the deadly calm, these noxious influences are neutralized, and the air becomes pure and salubrious. Moreover, the warm winds mitigate the rigor of the colder climes, and the cool winds temper the heat of the tropic regions. Their utility in reference to moisture will be shown in the next chapter.

CHAPTER III.

AQUEOUS PHENOMENA.

1. UNDER this division are included Rain, Fogs and Mists, Clouds, Dew, Hoarfrost, Snow, and Hail.

2. The moisture that rises from the sea and land, at all temperatures, is diffused throughout the atmosphere in an invisible state, and is supposed to occupy the intervals between the atoms of oxygen and nitrogen. An increase of temperature, by dilating the air, increases its capacity for moisture; while a decrease of temperature lessens its capacity. It has been found that if the temperature of the same volume of air is increased or decreased in an arithmetical ratio, its capacity is augmented or lessened in a geometrical series.

Thus, a cubic foot of air at 59° Fah. contains, when saturated, an amount of moisture equal to the eightieth part of its own weight; but for every twenty-seven additional degrees of heat its capacity is doubled: if it sinks twenty-seven degrees Fah., its capacity is halved.

3. **Wet and Dry Bulb Thermometer.**—The state of the atmosphere in respect to moisture is ascertained by hygrometers,—so called from the Greek words *ugros*, "moist," and *metron*, "measure." There are various instruments of the kind, but the most reliable is the wet and dry bulb thermometer. It consists of two thermometers, made as nearly alike as possible, the bulb of one being covered with muslin.

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30. What are Storm Charts? How are they employed? Explain their use in connection with the cyclone-tracks. 31. State what is said respecting the United States Coast Survey. 32. Mention the advantages arising from the winds.

What is the subject of Chapter III.? 1. What subjects are included under this division? 2. What is said of the diffusion of atmospheric vapor? What relation exists between the temperature of the air and its capacity for moisture? 3. What are hygrometers? Describe the wet and dry bulb thermometer, and how it is used.

When an observation is to be made, the muslin-covered bulb is moistened with water, which, evaporating, cools the enclosed bulb and lowers the mercury in the thermometer. When it has sunk as low as it will, the difference in the degrees of the two thermometers is marked, as well as the height of the wet-bulb thermometer. From these two observations the relative humidity of the atmosphere, as well as other important particulars, can be deduced by the aid of scientific tables.

4. From the law just stated, it is evident that when the atmosphere rises in temperature, from whatever cause, it gathers into its recesses vast stores of vapor, and, when its temperature sinks, is unable to retain it all. The superabundant moisture then falls in rain upon the parched earth, floats in clouds in the azure sky, hangs in mist-wreaths upon the mountains, and sparkles in dew-drops upon the slender grass. And if the loss of heat is excessive, the rattling hail descends, the hoarfrost fringes the withered herbage, and the starry snow-flakes fall noiselessly upon the earth.

Rain.

5. Whenever bodies of warm and cold air mingle, they are unable, united, to retain the same amount of moisture that they can separately hold, owing to the fact that their capacity diminishes faster than their temperature. Under these circumstances, when the difference of their temperatures is considerable, a portion of their previously invisible vapor is no longer retained, and this excess, gathering into drops, descends as rain. The chief natural agents in effecting such combinations are the winds.

Thus, rain is caused by cold blasts sweeping down from the mountains into the warm valleys, by warm winds being driven up the slopes of the mountains, and by the conflict of great aerial currents, which, differing in temperature, are constantly traversing the atmosphere in all directions, bringing rain to almost every part of the globe.

6. **Distribution of Rain.—Effect of Latitude.**—For the reasons already assigned, it is clear that the higher the mean temperature of any region is, the greater is the amount of its atmospheric moisture. We should, therefore, expect to find that the annual quantity of rain at the sea-level ~~in~~decreases from the equator to the poles; and this, as a general rule, is the case, as appears from the annexed table:—

		Annual fall of rain.
Paramaribo, Guiana	5° 40′ N. Lat.	229 inches.
Sierra Leone	8° 30′ "	189 "
Grenada (Little Antilles)	12° 15′ "	103 "
Macao	22° 11′ "	68 "
Savannah, Ga.	32° 05′ "	49 "
London	51° 31′ "	25 "
Upsal	59° 54′ "	16 "
Uleaborg	65° 1′ "	13.5 "
Maranham	2° 31′ S. Lat.	280 "

It is also proved by the annual amount of rain that falls in the different zones; for while in the torrid zone the mean yearly rain-fall is ninety-six inches, only thirty-seven inches of water descend in the north temperate zone, and thirty-three in the south temperate.

This rule is, however, subject to many exceptions, arising from various disturbing local influences, such as the nature and configuration of the land, and the prevalence of winds and currents.

Thus, at Bergen, in Norway, the warm and moist southwestern winds, checked by the Kiölen Mountains, produce an annual rain-fall of eighty-eight inches, but on the Baltic side only twenty-one inches fall in a year. At Rio Janeiro, in Brazil, the annual rain-fall is fifty-eight inches; while through the same latitude on the western coast stretches the rainless district of Peru.

Though more rain falls within the tropics than in the temperate zones, the number of rainy days in the year is less; and, as a general rule, it decreases with the increase of latitude. According to Müller, the yearly average of rainy days in Southern Europe is 120, in Central Europe 146, and in Northern Europe 180.

7. **Maritime and Inland Regions.**—The air over the sea and shore is always more humid than that above the land; and on this account the quantity of rain decreases from the coast to the interior of a continent. Thus, in the United States, while the annual rain-fall on the coast ranges from forty-two to sixty-five inches, on the great plains between the Mississippi and the Rocky Mountains it sinks as low as thirteen inches. In Europe, likewise, the rain-fall on the western coast varies from thirty to one hundred and eleven inches, while in Central and Eastern Europe it is about fifteen inches.

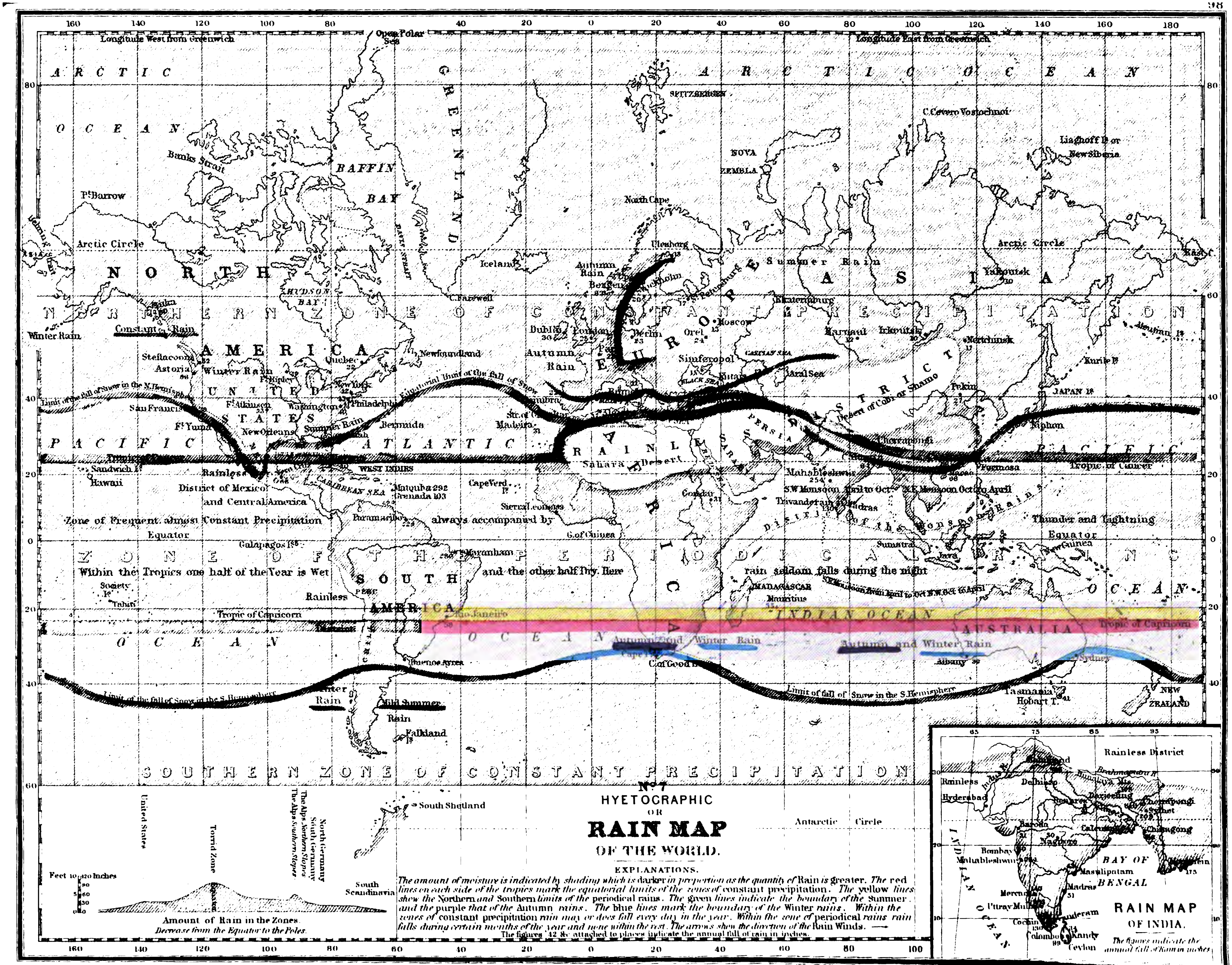
More rain descends upon the western coasts of continents and islands than upon the eastern, as far as observations have been made. In the United States the annual amount of rain on the eastern coast, between 40° and 45° north latitude, is forty-two inches, while between the same parallels on the western coast it ranges from forty-five to sixty-five inches. According to Johnston, the mean annual fall of rain on the western side of England is 50 inches, and on the eastern 27.4. In Ireland, the westerly rain-fall is 47.4, and the eastern 29.7. The moist southwestern winds give rise to this phenomenon in Europe; and the same cause is assigned for the excess of rain on the coast of Oregon.

8. **Effect of Height.**—The temperature of the air decreasing with its altitude, its capacity for moisture also decreases: there must, consequently, be less vapor in the atmosphere the higher we ascend, and, we should naturally suppose, less rain. This is true in respect to moderate elevations, and as we ascend from low plains to lofty table-lands. The annual depth of rain on the roof of York Minster was found to be 14.9 inches, while on the ground, 213 feet below, it was 25.7 inches. It appears from Johnston that, while the mean annual rain-fall upon the coast of Spain and Portugal varies from twenty-five to thirty-five inches, on the high table-lands of Castile it is only ten inches.

In the United States the same fact is observed in the Pacific region; for while on the coast the annual quantity of rain rises as high as sixty-five inches, it ranges on the Rocky Mountain plateau only from three to fifteen inches. Where, however, the warm winds of the plains, charged with vapor, drive up the cool slopes of lofty mountains, the amount of rain increases with the altitude up to a certain point, beyond which it decreases.

The peninsula of India presents more striking examples of this fact. The Ghaut Mountains, running parallel to the coast, arrest the moist southwest monsoon, and cause a vast precipitation of rain on the Malabar shores. At Trivanderam, situated in 8° 53′ north latitude, and 130 feet above the sea, the annual rain-fall is sixty-four inches; while at Mahableshwur, which is in 17° 56′ north latitude, and 4500

What can be ascertained by the wet and dry bulb thermometer? 4. What results flow from the law of capacity? 5. What is the cause of rain? How is the union of warm and cold currents chiefly effected? 6. What is the law of distribution in latitude? Give instances proving the law. Is it subject to any exceptions? Name these exceptions. What is the law as to the number of rainy days in a year? Illustrate this law. 7. What is said of the relative amount of rain in maritime and inland regions? Cite the illustrations. What is said of the rains on the eastern and western coasts of continents and islands? Give instances. 8. State what is said of the effects of altitude on the rain-fall. Give the proofs. Give an account of the rain in the peninsula of India.


Longitude West from Greenwich
Longitude East from Greenwich
Open Polar Sea
ARCTIC OCEAN
ARCTIC OCEAN
GREENLAND
BAFFIN BAY
NORTH AMERICA
UNITED STATES
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
PACIFIC
ATLANTIC
INDIAN OCEAN
OCEAN
NORTHERN ZONE OF CONSTANT PRECIPITATION
ZONE OF THE PERIODICAL RAINS
SOUTHERN ZONE OF CONSTANT PRECIPITATION
Zone of Frequent almost Constant Precipitation always accompanied by Thunder and Lightning
Within the Tropics one half of the Year is Wet and the other half Dry. Here rain seldom falls during the night
Rainless District
Sahara Desert
Desert of Gobi or Shamo
Equatorial limit of the fall of Snow
Limit of the fall of Snow in the N. Hemisphere
Limit of the fall of Snow in the S. Hemisphere
Limit of fall of Snow in the S. Hemisphere
Summer Rain
Autumn Rain
Winter Rain
Constant Rain
Autumn and Winter Rain
Mid Summer Rain
S.W. Monsoon, April to Oct.
N.E. Monsoon Oct. to April
Tropic of Cancer
Equator
Tropic of Capricorn
Arctic Circle
Antarctic Circle
South Shetland
North Germany
South Germany
The Alps Northern Slopes
The Alps Southern Slopes
South Scandinavia
United States
Torrid Zone
Equator
Feet
Inches
Amount of Rain in the Zones.
Decrease from the Equator to the Poles.
Rainless District
RAIN MAP OF INDIA.
The figures indicate the annual fall of Rain in inches
BAY OF BENGAL
INDIAN OCEAN

Nº 7

HYETOGRAPHIC
OR
RAIN MAP
OF THE WORLD.

EXPLANATIONS.

The amount of moisture is indicated by shading which is darker in proportion as the quantity of Rain *is* greater. *The* red *lines on each side of the tropics mark the equatorial limits of the zones of* constant precipitation. *The* yellow *lines shew the* Northern *and* Southern *limits of the* periodical rains. *The* green *lines indicate the boundary of the* Summer, *and the* purple *that of the* Autumn *rains. The* blue *lines mark the boundary of the* Winter *rains. Within the zones of* constant precipitation *rain may or does fall every day in the year. Within the zone of* periodical *rains rain falls during certain months of the year and none within the rest. The arrows shew the direction of the* Rain Winds. ⟶

The figures 42 &c attached to places indicate the annual fall of rain in inches.

feet above the sea, no less than two hundred and fifty-four inches descend annually,—more than twenty-one feet.

But all this is exceeded by the amount which pours down at Cherrapongi, an elevated station in the Himalayas, which here stretch away to the northwest, their lofty ranges gathering in and condensing the vast stores of moisture borne by the winds from the Indian Ocean. It is beyond dispute that six hundred and ten inches of rain fall yearly at Cherrapongi; and of this, five hundred and fifty inches descend between May and November. Drs. Hooker and Thomson once recorded thirty inches of rain in twenty-four hours. These are the greatest annual and daily rain-falls that have ever been observed.

It has been stated that the annual rain-fall in the north temperate zone is thirty-seven inches, and that in the south temperate zone thirty-three inches. The cause of this discrepancy may be attributed to the fact that in the Northern Hemisphere the ratio of land to water far exceeds that of the Southern, and the fluctuations in the temperature of the air, which give rise to rains, are consequently greater.

9. **Rains within the Tropics.**—Within the torrid zone the year is divided into two seasons,—the wet and the dry. For a period varying from three to five months, rain falls in great quantities, while during the remainder of the year scarcely any occurs. The rainy season begins with the shifting of the monsoons, which depends upon the position of the sun: it therefore commences earlier in places near the equator than in those which are more distant. In the Northern Hemisphere the rainy season begins in April and extends to October, the dry season comprising the rest of the year. In the Southern Hemisphere the periods are reversed, the rainy season lasting from October to April, while the dry season extends from April to October.

In Africa, near the equator, the rainy season begins in April, but does not reach Senegambia, more than ten degrees north, before the beginning of June. At Panama the rainy season begins in March, but at San Blas, in California, it does not occur till the middle of June.

RAINY SEASON,—BEGINNING OF THE MONSOON.

The rainy season commences with storms of the most terrific nature, especially in the peninsula of India. "Its approach," says Mr. Elphinstone, "is generally announced by vast masses of clouds that rise from the Indian Ocean and advance towards the northeast, gathering and thickening as they come to land. In a few days the southwest monsoon sets in, attended by thunder-storms far exceeding in intensity those of the temperate climes: for hours the lightnings blaze without intermission, amid the ceaseless rolling and crashing of the thunder. At length the thunder ceases, and the rain for days descends in torrents, swelling the rivers and deluging the plains. Ere long the storm subsides, and the earth, which before was parched and dry, is suddenly clothed with bright and luxuriant verdure."

The periodical rains within the tropics are evidently caused by the sun, which in his annual progress gives rise to the southwestern monsoon in the Northern Hemisphere, and to the northwestern in the Southern. Each of these great currents bears from the equatorial seas vast stores of moisture, which are condensed over the land and fall in refreshing rains upon the earth.

In India, on the Coromandel coast, the times of the seasons are reversed, the heat being very great from June to October, while from October to the middle of December the stated rains prevail. As the sun passes and repasses from one tropic to another, there is, in most intermediate places, a twofold rainy season, the two periods being more or less closely connected in point of time. Thus, in Congo two rainy seasons occur, the first extending from October to January, the second from March to the middle of May.

10. **Rains beyond the Tropics.**—In the extra-tropical regions, where there are no periodical winds, but the currents of air are ever changing, the rains are distributed throughout the year with great irregularity, and are controlled by no law yet discovered. In Germany twice as much rain falls in summer as in winter; while in the west of England the winter rains are eight times greater than those of summer. In the countries of Southern Europe the winter rains are in excess; but in those of Western Europe the autumnal rains predominate.

11. **Rainless Districts.**—Stretching in an immense belt across the Eastern Continent, and interrupted only by mountain-ranges, is a vast tract, comprising regions upon which rain never falls, and others where it descends only at widely distant intervals of time and in minute quantities.

This belt begins in Africa, at Morocco, and stretches eastward over the Sahara, Egypt, Arabia, and Persia, to the base of the Himalaya Mountains. Beyond these it is continued in the vast Desert of Cobi, the table-land of Thibet, and part of Mongolia. This immense region is computed to be 6,000,000 of square miles in extent. A minor belt occurs near the Orange River in South Africa, and includes large regions in Australia.

In the Western Hemisphere the rainless tracts embrace the table-land of Mexico, a portion of Guatemala, and a narrow strip of land that skirts the base of the Andes in Peru and stretches along the coast for the distance of 540 leagues. These regions comprise an area of about 500,000 square miles.

The want of rain in these localities is explained in different ways, according to the peculiarities of their several situations. The intense heat of the African Sahara gives to its atmosphere so great a capacity for moisture that the vapor borne thither from the Mediterranean and Atlantic is retained in its invisible state, and there are here no cool mountain-heights where it might be condensed into rain.

South of Egypt, the moisture borne by the north winds up the

Where does the greatest annual and daily rain-fall on the globe occur, and why? Why does more rain fall in the northern temperate zone than in the southern? 9. How is the year divided within the tropics? Describe these seasons, and mention the times of their occurrence in the Northern and Southern Hemispheres. Describe the commencement of the rainy season in India. What is the cause of the periodical rain? What other facts are stated in respect to this season? 10. What is said respecting the rains beyond the tropics? Give the facts. 11. Give an account of the different rainless regions, and explain this peculiarity

Abyssinian ranges descends in floods, which cause the inundation of the Nile. To this Egypt owes its amazing fertility, for it is a country where rain scarcely ever falls; and this has been the case from the earliest times, for about two thousand four hundred years ago the prophet Zechariah spoke of Egypt as the "land that has no rain."

In the great Desert of Cobi, the northerly land-winds are dry, while towards the south the high ranges of the Himalayas effectually intercept the moisture borne from the Indian Ocean by the southern winds. In like manner moisture is cut off from the arid and elevated regions of Persia, by encircling ranges of mountains. To a like cause is attributed the existence of the rainless regions of the Western Continent. The humid southeast trade-wind, sweeping across the boundless plains and pampas up the eastern slopes of the Andes, loses nearly all its humidity before it passes these lofty mountains; and the plains of Peru are, consequently, destitute of rain.

12. **Regions of almost constant Rain.**—Near the equator, in the zone of variable winds, light and changing breezes are perpetually alternating with calms, and rains are almost constantly occurring. In the low plains of Guiana, shrouded by impenetrable forests and swept by the moist trade-winds, rain falls, according to Humboldt, for five or six months almost without intermission. At the island of Sitka, on the northwest coast of America, there were no less than one hundred and twenty days of uninterrupted rain and snow in the year 1828, and only sixty-six days when the sky was perfectly clear; and there have been years in which only forty dry days have been observed. This peculiarity is attributed to the fact that the coast here, bending to the west, meets the full sweep of the southwest winds, while its mountain-ranges arrest them and condense their vapors.

13. **Rain without Clouds.**—The moisture precipitated from the atmosphere sometimes descends at once as rain, without passing through the intermediate state of cloud. During the month of February, 1852, a copious rain fell at Washington, D.C., for the space of several minutes, from a perfectly cloudless and starlit sky. Many other instances of this kind have been observed.

14. **The Annual Rain-Fall of the Globe.**—According to Johnston, the annual fall of rain in the torrid zone is 8.5 feet, in the temperate zone, 3.05, and in the frigid zone, 1.25,—an amount which, taking into account the surfaces of the respective zones, would cover the earth to the depth of about five feet. It is sufficient, from the computations of Maury, to form a lake 24,000 miles long, 3000 broad, and sixteen feet deep.

Fogs and Mists.

15. Fogs and mists are visible vapors that float near the surface of the earth. When a body of cool air mingles with one that is warmer and humid and which differs from it but slightly in temperature, little moisture is precipitated, and fogs and mists occur. In rain the condensed vapor gathers into drops; but fogs consist of countless numbers of minute, hollow, watery globules, the size being greatest when the air is very humid. A difference in temperature of from 3° to 6° Fah. in the combined volumes of air is sufficient, in some cases, to produce a fog. The mist which is seen in a hot summer day over the ice in an ice-cart illustrates the formation of fog.

16. **Distribution of Fogs.**—In the polar regions dense fogs prevail throughout the year. In the summer the air over the land becomes warmer than that over the sea, and heavy fogs arise from their union. In the winter the case is reversed: the sea is warmer than the land; but the result is the same. Over the open sea then hangs a cloud of mist, termed the *frost-fog*. So extensive and dense are these fogs that they render navigation extremely dangerous. Captain Kane, when conducting the Grinnell Expedition, was obliged on one occasion to heave-to his vessel in the midst of a fog, the mist being so thick that no objects were visible half a ship's length from the deck.

In the temperate climes, fogs occur at intervals and in confined localities. In the tropical regions, they prevail just before and after the rainy seasons, when but little moisture is contained in the air.

Where warm or cold currents traverse the ocean, the air above them partakes of their respective temperatures, and the fluctuations of the atmosphere produce frequent and dense fogs. The sea-coast, for the same reason, is subject to fogs, since its temperature differs from that of the adjacent ocean; and the waters of shoals, being cooler than those of the deep sea, are often covered by heavy mist.

It is for this reason that dense fogs prevail to such an extent on the Banks of Newfoundland, near the Gulf Stream, and also shroud the Aleutian Isles. From April to October a heavy mist overhangs the city of Lima, in Peru; for along this coast a cold current flows, having a temperature of 9° Fah. below that of the surrounding ocean.

Fogs during the nights of summer gather over moist valleys, and also along the banks of rivers; because, although the land becomes warmer in the daytime than the water, it is colder during the evening and night, since it radiates heat more rapidly than water; the masses of the air above them partake of their respective temperatures, and, mingling together, give rise to fogs. When in spring a river during a warm day is filled with floating ice, fogs shroud the stream, the air over the river being colder than that above its banks.

Warm winds sweeping up the cool sides of mountains give rise also to fogs. Cool moist winds from the sea driving upon warm coasts produce the same phenomenon; and a soft southern breeze in spring, sweeping over the melting snow, shrouds it in a veil of mist.

17. **Dry Fog, or Haze.**—When the sky is cloudless, and during seasons of great heat, it is at times obscured by a haze more or less dense, which is termed a dry fog, since it is not the result of aqueous deposition. In 1733 a fog of this nature overspread the kingdom of France, and in 1783 another extended over the greater part of Europe, so dense as partially to obscure the sun. This phenomenon has been attributed to the prevalence of smoke caused by extensive fires, and, as it has also been found to coexist with earthquakes and volcanic eruptions, it has been supposed to have some connection with them; but no sufficient explanation has yet been discovered. Under the head of dry fog is classed the Indian Summer haze, which has not received any satisfactory elucidation.

Clouds.

18. Clouds are nothing more than fogs floating in the higher regions of the atmosphere. One prolific source of clouds is the uprising of warm currents of air during the day from the heated surface of the earth. The rising columns of air gradually sinking in temperature the higher they ascend, their capacity for moisture is constantly diminishing, until at last they are unable to retain all that they possess, and the excess becomes visible as a cloud. If the column of air is now borne higher, the cloud increases; if it sinks towards the earth, the vapor is dissolved, and the cloud disappears.

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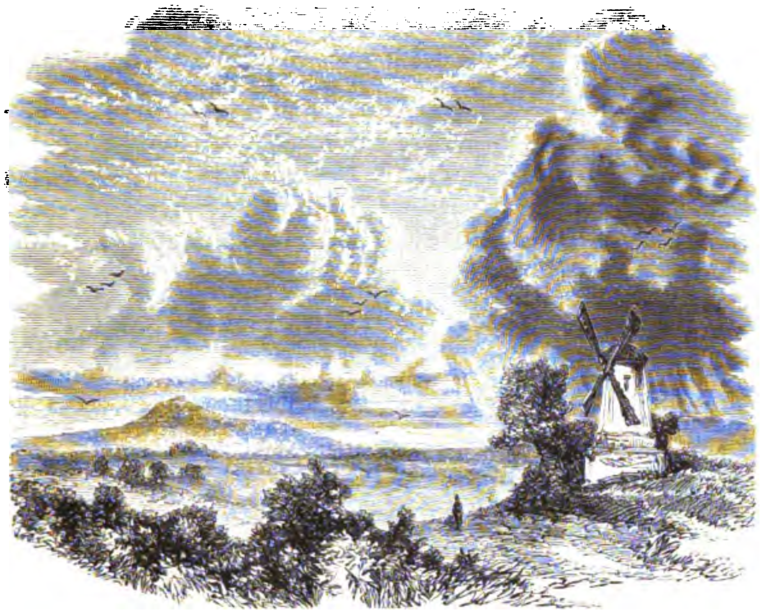
in these localities. 12. Do we find regions of almost constant rain? How are these facts to be explained? 13. Does rain ever occur without clouds? Why? Give the instance cited. 14. What is the annual rain-fall of the globe? 15. What are fogs and mists? How are they caused? Give the illustration. 16. Give the facts respecting the distribution of fogs, and explain the causes of their occurrence in the regions and places and at the times mentioned. 17. What is said of dry fogs? 18. What are clouds? How do they originate?

19. **Height of Clouds.**—Clouds range in height from about 1300 feet to nearly five miles. Gay-Lussac, in the month of September, 1804, ascending in a balloon to the altitude of 23,000 feet, beheld even there clouds floating far above him.

Mr. Crosthwaite found, from 5371 observations made at Skiddaw, a mountain in Cumberland, England, that the clouds in 3270 observations were below the height of 3000 feet. It is probable that they are more frequently below than above a mile in altitude.

The thickness of clouds is sometimes very great. Two French engineers measured amid the Pyrenees a stratum of cloud that was more than half a mile thick.



NOMENCLATURE OF CLOUDS.

Stratus or Pall cloud

Cirrus or Curl cloud.

Cumulus or Day cloud.

Nimbus or Rain cloud.

20. **Classification of Clouds.**—Mr. Luke Howard has divided clouds into seven classes, distinguished by their forms,—viz.: three primary, the *Cirrus*, *Cumulus*, and *Stratus;* and four compound, the *Cirro-cumulus*, *Cirro-stratus*, *Cumulo-stratus*, and *Nimbus*.

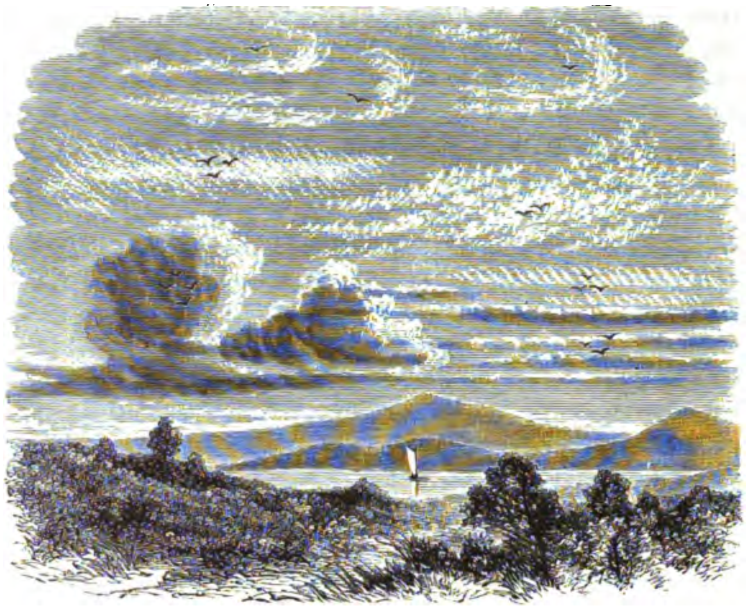
The *Cirrus* consists of slender white filaments, curling at times like a lock of hair, or arranged in parallel lines. It frequently resembles a delicate network of vapor, or spreads over the sky in light, feathery forms. Of all the clouds, the cirrus soars highest, above the region of perpetual frost, and is supposed to be entirely composed of snow-flakes. It is regarded as the precursor of a storm.

The *Cumulus*, or day-cloud, floats near the earth, and is caused by the uprising of the heated currents of air. It appears in vast rounded masses, which increase in size towards the hottest part of the day. They not unfrequently appear like immense snowy mountains, with deep, shadowy gorges and radiant summits.

The *Stratus*, or pall-cloud, is an extended level sheet of vapor, which appears in the evening and melts away with the advance of the morning. It is caused by the vapors which have been exhaled during the day and which return to the earth when its temperature falls at the approach of night.

The *Cirro-cumulus*, which is a modification of the cirrus and cumulus, is a fleecy cloud, occurring in small, rounded masses lying near to each other. It exists at various altitudes, and is seen in summer in the intervals of showers.

The *Cirro-stratus*, which consists of bands of vapory threads more compact than those of the cirrus, groups itself into different forms. Sometimes it is composed of parallel bars of vapor, either distinct, or blended at their centres, and at others appears as a long and slender band. The slight vapory haze which occasionally dims the brilliancy of the sun is another form of the cirro-stratus.



NOMENCLATURE OF CLOUDS,—SECONDARY FORMS.

Cirrus.

Cirro-cumulus.

Cirro-stratus, various forms.

Cumulo-stratus.

When masses of cumulus clouds rise from the same horizontal stratum, the *Cumulo-stratus* is formed. Frequently contiguous clouds unite, and vast vapory masses roll upward, and pile upon each other like Alpine ranges. This is the case before thunder-storms. No other clouds equal in grandeur the cumulo-stratus.

The *Nimbus*, or rain-cloud, is usually formed from some of the preceding varieties. It is a dense cloud, with a ragged outline, passing below into rain. It first appears of a bluish-black color, and then changes to a light gray shade.

Dew.

21. Dew is the moisture spontaneously deposited upon objects freely exposed to the atmosphere, in the absence of fogs, rains, hail, and snow; and originates as follows:—

During the day the surface of the earth is gradually heated by the sun's rays, and the air above it partakes of its rising temperature, increasing in its capacity for moisture. Towards evening, and throughout the night, both the air and the land, with its varied vegetation, lose their heat by radiation; but the latter cools more rapidly than the former, and, a stratum of air in contact with the colder earth then sinking in temperature below the point of saturation,—called the dew-point,—the excess of moisture gathers in drops upon various objects, in the form of dew.

Dew never collects upon any object until it is colder than the contiguous air. The condensation of the moisture of the atmosphere, in a hot day, upon the outside of a goblet filled with ice-water, illustrates the principle of the deposition of dew.

22. **Deposition of Dew.—How influenced.**—A cloudless sky favors the deposition of dew; for the radiation of heat from the earth then goes on unchecked, and its surface sinks rapidly in tempera-

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19. What is said of their height? 20. How are they classified? Describe the several classes. 21. What is dew? How is it caused? What is the dew-point? When does dew collect upon any object? Give the illustration. 22. What states of the atmosphere are favorable to the deposition of dew?

ture. But clouds arrest the radiation, and, the earth preserving its temperature, no dew is formed.

The effect of clouds is often very striking. Dr. Wells, an eminent meteorologist, once observed the following changes. A thermometer lying in the grass, under a serene sky, indicated a temperature of 32° Fah.; twenty minutes after, when the sky was overcast, it rose to 39° Fah.; in twenty minutes more, the sky being clear, it sunk to 32° Fah. More dew is deposited on a calm than on a windy night.

Dew is deposited most abundantly upon those bodies which have rough and pointed surfaces, and which are likewise good radiators but bad conductors of heat. Thus, down, wool, low shrubs, and grass, are often drenched with dew; and on the rough-pointed leaves of the melon and cucumber dew sometimes begins to collect when the sun is high in the western heavens. The reason of this is that uneven surfaces and points radiate heat very rapidly, and these bodies thus losing their heat are unable, being bad conductors, to supply their loss from the warmer substances with which they may be in contact. Upon rocks, and metals in contact with the ground, no dew is deposited; for whatever loss of heat these bodies may sustain by radiation they regain from the warm earth, as they are good conductors.

These remarks apply to bodies freely exposed to the atmosphere. If they are screened in any manner from the open sky, by trees or otherwise, the amount of dew contracted is materially lessened, for reasons before stated. Color has no effect upon the deposition of dew.

23. **Distribution.**—Dew is abundant in maritime regions; but little is deposited in the interior, except in the vicinity of lakes and rivers. In the temperate climes, the amount of dew is small. According to Dr. Dalton, the annual quantity of dew in England would cover the whole kingdom with a sheet of water five inches in depth. Within and near the tropic countries, the dews are very abundant, and drench the low verdure like rain. In the Holy Land, and some other parts of Western Asia, it is so copious that for weeks it moistens the earth during the absence of showers, and sustains its vegetation.

HOARFROST.

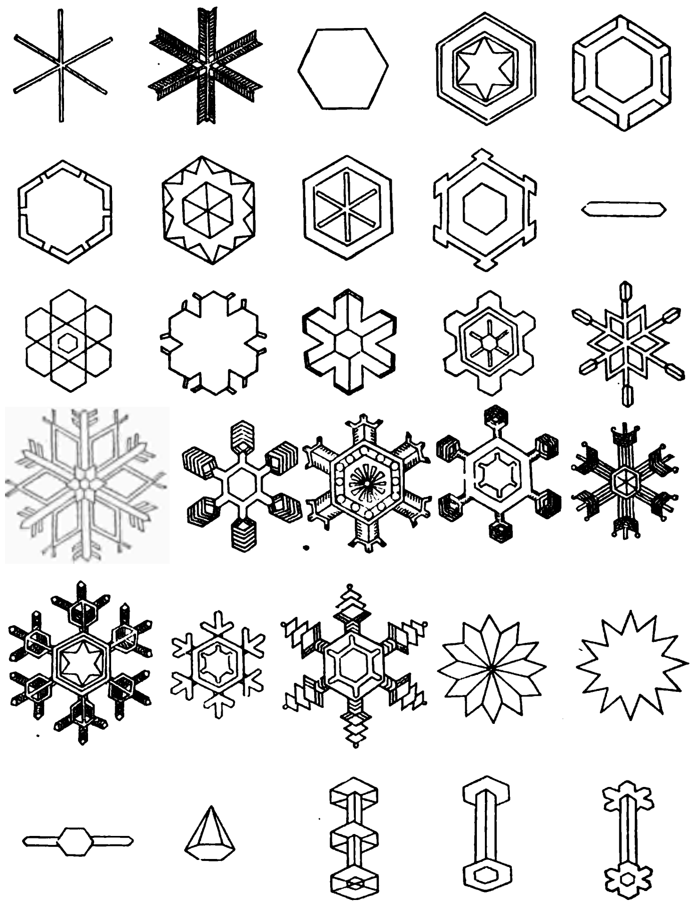
24. When, during the night, the bodies upon which dew is forming sink to the temperature of 32° Fah. or below it, the condensed moisture is frozen, and becomes *hoarfrost*. It is the ice of dew. The minute portions of vapor, being frozen as they are successively condensed, do not appear as congealed dew-drops, but in masses of delicate crystals, which clothe the low shrubs and spires of grass with fringes of rare beauty.

Hoarfrost occurs at the beginning and close of winter, when the air is moist and the nights are cold. During the winter, when a warm and moist south wind occurs, the surfaces of stone walls and columns are covered with an incrustation of delicate white crystals, formed from the atmospheric vapor condensed in the same way as hoarfrost.

SNOW.

25. When the temperature of the air at the surface of the earth is near or below the freezing point, the condensed moisture of the atmosphere is congealed, and descends in flakes of snow,—the flakes being usually larger as the moisture is more abundant.

At times the falling snow gathers into masses formed by the aggregation of the flakes. In 1853 a singular occurrence of this kind was observed at Royalton, Vermont. While it was snowing fast and the wind was high, it seemed as if flocks of geese were descending to the ground; but it was soon ascertained that this appearance was produced by balls of snow formed in the air by the action of the wind. Upon measuring these masses after their fall, some of them were found to be twenty inches in diameter.



SNOW-CRYSTALS.

Red snow is sometimes found in the polar climes and in Alpine countries, its color being caused by the presence of a minute plant, termed the *protococcus nivalis*, which grows in those regions with extraordinary vigor.

In countries where the cold is intense, illustrations of the mode in which snow is produced are by no means of unusual occurrence. In Russia, during the winter, when a window of a warm room is opened and the cold air is admitted from without, a shower of snow-flakes fills the room, caused by the union of the warm and cold bodies of air.

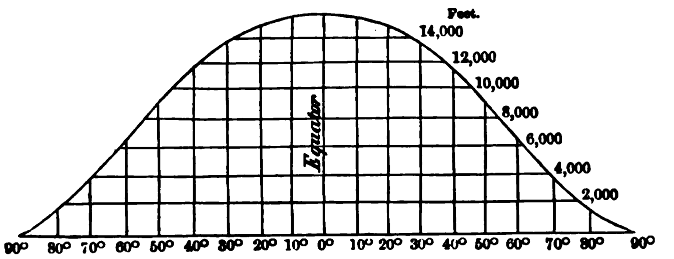
26. **Snow-Flake.**—When carefully examined, the snow-flake is found to consist of an assemblage of delicate and regular crystals, combining in a great variety of beautiful forms. Its brilliancy and whiteness are due to the presence of air within the crystals. According to Dr. Scoresby, a celebrated Arctic explorer, no less than six hundred varieties exist, ninety-six of which he delineated. The foregoing cut exhibits thirty of the most remarkable forms which he observed.

27. **Distribution of Snow.**—No snow falls at the sea-level within the torrid zone and for a varying distance beyond it. In the Northern Hemisphere the southern limit of snow, termed the snow-line (see Rain Map, p. 98), is for the most part included between the parallels of 20°

What is said of the nature, form, and color of bodies in reference to this point? Give the illustrations. 23. State the facts given in regard to the distribution of dew. 24. What is hoarfrost? Explain how it is formed. 25. Under what circumstances does snow occur? What curious fact is mentioned which occurred in Vermont? Where is red snow found? What is its color due to? Are illustrations of the mode in which snow is formed uncommon in countries where the cold is intense? What one is given? 26. Describe the snow-flake. What is said of their form?

and 40°. In the Western Continent it traverses California, Mexico, and the Southern States, and, extending over the Atlantic, rises there as high as 43° north latitude. In the Eastern Continent it passes through Algiers, in 36° north latitude, and, advancing eastward, traverses the Caspian Sea, Canton, and the island of Niphon. North of this line the snow-fall is greater as the latitude increases; and the number of snowy days in the year follows the same law. Thus, while there are in Rome 1½ days of snow in the year, Paris has 12, Copenhagen 30, and St. Petersburg 171. In the polar climes, ice and snow prevail throughout the year.

Our knowledge of the Southern Hemisphere on the above points is imperfect; but the snow-line, according to the best authorities, rises in the Pacific to about the forty-third degree of south latitude, and, sweeping eastward, passes through Chili and the Cape of Good Hope. Rising to about the same parallel in the Indian Ocean as in the Pacific Ocean, it afterwards crosses the southeastern coast of Australia. As we ascend higher and higher above the sea-level, the stores of atmospheric moisture are diminished, and the quantity of snow which falls is less than that which descends in the lower districts; but, as we continue to rise, an altitude is at length attained, in every latitude, where the falling moisture is constantly frozen, and the mountain-ranges that tower above this limit are always clothed with the vast accumulations of ice and snow which have been gathering for ages. An imaginary line drawn from pole to pole through these altitudes where moisture is always congealed, is called the snow-line, or line of perpetual congelation. Near the equator it is highest, being there about 16,000 feet above the sea-level; and from this point it gradually sinks towards either pole. It is represented in the annexed figure.

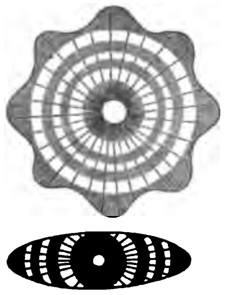


SNOW-LINE, OR LINE OF PERPETUAL CONGELATION.

HAIL.

28. Hail is the ice that falls during summer showers and storms, and is chiefly confined to the temperate climes. It is produced by the sudden union of an intensely cold body of air with one that is warm and humid.

29. **Hailstones.**—In their external appearance, hailstones are usually pear-shaped masses, but not uncommonly are angular and specular. A section of the stone through the centre reveals its internal structure, which consists of a snowy nucleus surrounded by concentric layers of ice, with rows of radiating air-bubbles,—the whole resembling the cross-section of a tree. The section and external appearance of the hailstone are shown by the annexed figures.



SECTION OF HAILSTONES.

HAILSTONE.

It is evident that the hailstone when first formed is small, and gradually increases as it descends, from the moisture which freezes upon it. Hailstones vary greatly in magnitude, from the size of a pea to masses of several pounds' weight,—probably arising from the union of several large stones. In 1850 a most destructive hail-storm occurred at Pittsburgh, Pa. Many of the stones weighed from eight ounces to a pound and over, and measured from nine to fourteen inches in circumference. So great was the force with which the hail descended that the roofs of warehouses covered with sheets of iron were completely riddled with holes, some of them so large that a man's arm could be thrust through them.

30. **Origin.**—The explanation of hail-storms involves much difficulty, inasmuch as the production of ice in the air during the hottest part of the year and of the day is to be fully accounted for. In most instances, however, the phenomenon is readily traced to its origin; but in others the problem remains unsolved. The union of a warm and humid body of air with one that is exceedingly cold is necessary, as already stated, to the formation of hail; and this combination may occur in several ways, the principal of which appear to be the following:—

1st. By the descent of intensely cold winds from lofty and ice-clad mountains into the warm plains below. To this cause are attributed the destructive hail-storms which so frequently ravage the south of France lying between the Alps and the Pyrenees.

2d. Whirlwinds, whose axes are inclined to the horizon, bring down cold air and carry up warm air, and may thus occasion such a combination as to produce hail.

3d. A warm current may be arrested by a cold current suddenly sweeping across its path, causing the warm air to be driven higher up into the atmosphere. An event of this kind occurred in the Connecticut Valley, in the vicinity of Hartford, on the 9th of August, 1851. A warm southwestern wind prevailed until about five o'clock, when suddenly a tempest burst from the northwest, sweeping over a track thirty miles wide. The temperature sank 20° Fah. in half an hour, and torrents of rain descended, accompanied by showers of hail. The southwesterly wind, checked by the cold northwest wind, overrode the latter, and, rising high into the colder regions of the atmosphere, produced the hail.

4th. Hail has been attributed to the union of a cold wind blowing from the polar regions, above the line of perpetual congelation, and meeting, within the temperate climes, with a warm wind having the same altitude, but coming from the equatorial regions far below the snow-line. By the inspection of the curve of congelation, it will be seen that its form will admit of this supposition. Hail-storms occur at times within and near the tropics. In India, in 1823, hailstones fell at Hyderabad, 17° north latitude, in such quantities that the servants of a military mess collected enough to cool their wine for several days.

31. **Alpine Snow-Fields.**—Above the limits of perpetual congelation the mountains are always covered with enormous masses of snow, and of ice formed by its partial thawing. In these lofty regions, vast snow-fields spread out between their gorges and rest on their broad, irregular slopes. The highest peaks are also clothed with immense bodies of snow. On Mont Blanc it is computed to be two hundred feet thick.

32. **Avalanches.**—When the snow upon these mountainous de-

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27. What is said of the distribution of snow in latitude and in altitude? What is the snow-line? 28. What is hail, and how is it produced? 29. Describe the structure of the hailstone. What is said of the size of hailstones? Describe the Pittsburgh hail-storm. 30. Why is the explanation of hail-storms difficult? Give the different theories, and the illustration. Do hail-storms sometimes occur within and near the tropics? Give the case cited. 31. What is said of the Alpine snow-fields? 32. What is an avalanche, and how caused? Describe the one mentioned.

clivities is loosened, either by its own weight or by the softening influences of the winds and the solar rays, immense masses are precipitated down the slopes, with irresistible violence, into the plains below, often destroying forests, burying villages, and arresting rivers in their courses. This is the avalanche,—the "thunderbolt of snow." In 1749 the whole village of Bueras, in the canton of the Grisons, was buried beneath an avalanche. One hundred persons were dug out of the snow, forty of whom were dead. In 1806, at Val Calanea, in the same canton, a forest was transported from one side of the valley to the other by the descent of an avalanche.

33. **Glaciers** are vast accumulations of ice of a peculiar nature, enclosed between the ranges of snow-clad mountains. The immense snow-fields lying above the line of perpetual frost are the sources of the glaciers: their upper boundaries meet this line, while the lower extremities extend downwards into the cultivated regions, where they end in walls of ice, bordered by the fragments of rocks and earth which they have carried along with them in their descent. The glacier has been likened by Professor Forbes to an icicle pendent from a snow-covered roof,—its magnitude being usually very small as compared with the extent of the snow-field where it originates.

Glaciers are, of course, situated highest in the torrid zone, their altitude decreasing with the latitude, until in the polar climes, where the ground is covered throughout the year with snow, they are found in immense masses at the sea-level.

The principal regions where glaciers occur are the frigid zones. In Europe, they are found in Norway, Iceland, amid the Alps and Pyrenees, and on the Caucasian ranges. In Asia, they are seen on the slopes of the Himalayas, but are rare on the Altai range. In South America, they commence, according to Mr. Darwin, on the west coast of Chili, in 46° south latitude, and from this point to Terra del Fuego—a distance of more than 600 miles—almost every arm of the sea is terminated by a magnificent glacier. In Africa, glaciers occur in the Atlas range.

34. **Extent.**—The glaciers of the Alps, which present the most perfect development of this singular formation, are between 500 and 600 in number, and, not including those of the Grisons, are estimated to cover an area of 1500 square miles. Some of these are of enormous magnitude: thus, the Glacier des Bois, which terminates in the celebrated Mer de Glace, is fifteen miles long and three broad, and varies in thickness from 80 to 600 feet. But in the polar climes their extent is vast beyond conception. In the Antarctic regions, in Victoria Land, they were seen in 1841, by Sir John Ross, extending from the mountains of the interior, filling all the ravines and valleys, and pushing out for miles into the sea. All the coast was lined by lofty precipices of ice.

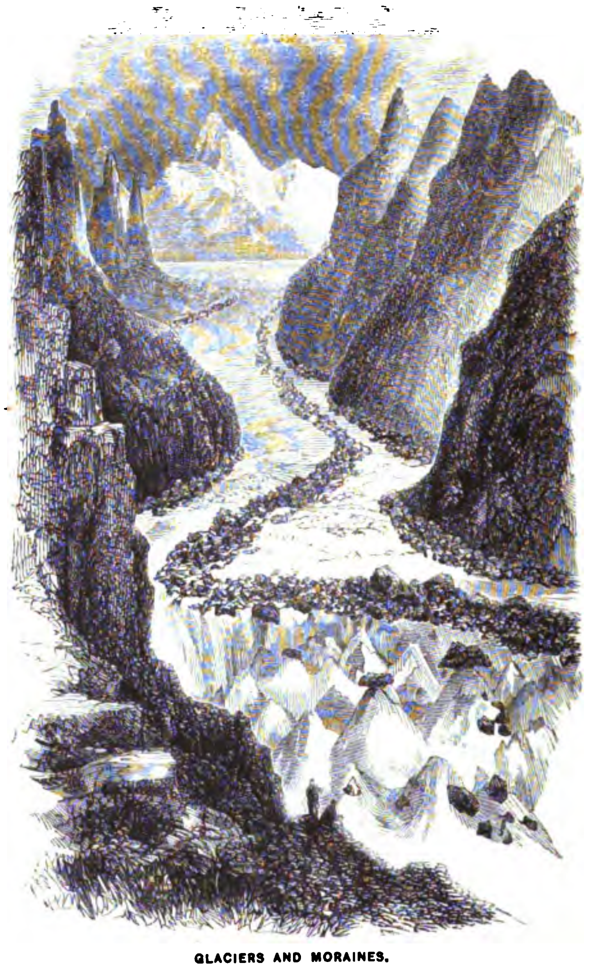
Of the ice-fields and glaciers of the Arctic region, Dr. Kane thus speaks:—"Imagine Greenland as sending down from the interior, through every fiord, mighty cataracts of ice, which stretch in stupendous barriers for leagues along the shores of the Atlantic and the Greenland Sea." One of these ice-cliffs, the Great Glacier of Humboldt, rises as a solid glassy wall from an unfathomable depth, three hundred feet above the ocean-level, and extends for a distance of sixty miles from Cape Agassiz to Cape Forbes.

35. **Formation, Structure, and Color.**—The glacier is formed by the freezing and thawing of the snow at the lower limits of the snow-field, and is crystalline in its structure, being composed of single crystals, irregular in form, and varying from an inch to three inches in length, wedged together in masses.

It consists of two kinds of ice, differing in hardness and color, and arranged in parallel plates,—thin sheets of compact and transparent ice alternating with others that are not so hard and are semi-opaque. The color of the former is a blue, passing through all shades, from the slightest tinge to the deepest hue of lapis-lazuli.

36. **Motion.**—The glacier is in motion, and descends in the direction of the valley on which it rests, at a rate varying from three or four inches to three feet per day, the slower motion being the more usual. Professor Forbes, with the aid of other observers, marked the progress of a glacier near Chamouni for nearly a year, and found that it had advanced 480 feet within that time. The icy mass of the glacier thus descends amid cultivated regions, and flowers bloom by its side; but the increased temperature of the lower slopes limits at length its progress, melting away the front of the advancing ice.

The motion of the glacier is variously accounted for. According to some philosophers, the water which penetrates the glacier, by its alternate freezing and thawing, dilates the icy mass and forces it forward; but Professor Forbes claims that a glacier is an imperfect fluid, or viscous body, which is urged down by the natural pressure of its parts.



GLACIERS AND MORAINES.

37. **Moraines.**—Fragments of rock and earth, loosened by the frost, are precipitated upon the glacier from the mountains that flank its sides. As it advances down its enclosing valley, this loose

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33. Give a description of glaciers. Where are they found? 34. What is said of their extent? 35. Of their formation, structure, and color? 36. Give an account of the motion of glaciers. How is this motion caused? 37. What are moraines? What particular name is given to them?

matter is carried with it, and is found accumulated on the borders of the glacier and at its lower end. These accumulations are respectively called *lateral* and *terminal* moraines. When two glaciers come together, the inner lateral moraine unites in the midst of the new glacier, and constitutes a medial or middle moraine.

38. **Avalanche of the Glacier.**—When the glacier ends upon the edge of a precipice, immense masses are often broken off and fall in ice-avalanches. A most disastrous catastrophe, resulting from this circumstance, occurred in the Valais, in the vale of Bagnes, in 1818. Here such immense blocks of ice had fallen from time to time from the glacier of Getroz, that the river Dranse became dammed up by a barrier of ice one hundred feet high, forming a lake of considerable size. Upon tunnelling this barrier, it was at once swept away, and a destructive flood rushed down the lower valleys, carrying away houses and crops and every thing before it. A rock, eighty feet in circumference, twelve feet high, and twelve broad, was borne down from the vale into the plain.

39. **Icebergs.**—The glacier is the parent of the iceberg. In the polar climes, the glacier, descending to the coast, pushes out into the ocean, whose waves are continually undermining it, until, from time to time, vast overhanging masses, unable to support themselves, break off and plunge into the sea.

Such a phenomenon was once observed in Greenland by Mr. Grudëitz, who saw a portion of a glacier crack off and float as an iceberg. It was three hundred yards long and fifty broad, and rose as high above the sea as a mainmast. In the opinion of Dr. Kane, however, icebergs, in general, are produced in a different manner,—the enormous masses of the glaciers being gradually propelled farther and farther into the ocean, until at length, reaching water capable of supporting them, they float upon its surface and are borne away by its numerous currents.

40. **Distribution of Atmospheric Moisture.**—The student of meteorology cannot fail to remark the admirable arrangement for the distribution of moisture which obtains throughout the world, and the minor provisions connected with it. The sun by its heat not only fills the atmosphere with vast stores of moisture, but at the same time gives rise to winds which carry this humidity all over the globe. There is also such a connection between heat and moisture, that the greater the warmth the greater the amount of atmospheric humidity, and the hottest countries have the most rains. It is also seen in the deposition of dews, that gather most copiously on that kind of vegetation which is at once the most perishable and the most useful.

CHAPTER IV.

CLIMATE.

1. "THE climate of a country," says Herschel, "is the result of all the meteorological influences to which it is habitually subjected." The controlling agencies are heat and moisture; but minor and local influences have their due effect.

2. The temperature and humidity of any region are modified by a variety of causes, the principal of which are *Latitude, Height above the Sea-level, Position and Direction of Mountain-Chains, Table-Lands, Proximity or Remoteness of the Ocean, Prevalent Winds and Currents, Nature of the Soil,* and *Cultivation.*

3. **Latitude.**—When the sun's rays fall vertically upon the atmosphere, more of them reach the surface of the earth than when they strike it obliquely. Now, since the axis of the equator is inclined to that of the ecliptic 23° 27′, it results that the solar rays come vertically to the earth throughout the year at some point or other within the tropics, while beyond these limits they ever strike the earth obliquely,—their inclination to the surface of the earth gradually diminishing towards either pole, but fluctuating at any given locality with the alternation of the seasons.

It thus occurs that the temperature decreases with the latitude, and in advancing from the equator towards either pole, we pass through every gradation of climate, from the fierce heats of the torrid zone to the eternal frosts of the polar climes.

The comparative lengths of day and night have also an important influence upon climate; for when the days are long there is a great accumulation of heat under the continued action of the sun; while only a little is lost by radiation during the short night. At the equator the days and nights are equal in length; within the tropics their inequality is slight; but in the higher latitudes they differ greatly in duration, while within the polar circles unbroken days and nights continue for months, alternating with the seasons. The variations of heat arising from the causes just mentioned are attended by corresponding variations in moisture, as we have seen in the preceding chapter.

The range between the summer and winter temperatures of the higher latitudes is very great, causing what are termed excessive climates. Thus, in the bleak regions of Norway the thermometer in summer rises as high as 80° Fah.; and grapes have ripened in the open air at Quebec, where in winter the mercury, sinking to 40° Fah. below zero, becomes congealed.

The effect of the solar heat extends but a short distance below the surface of the soil; for at a depth varying from about forty to one hundred feet, a stratum of earth is reached where the temperature never changes, and which is about the same as the mean temperature of the country above it. It will be readily seen that this stratum lies deepest in the hottest countries.

4. **Height above the Sea-Level.**—We have seen that, on account of the decrease of temperature with the increase of height, while the base of a mountain-range is glowing with tropical heat, its loftiest peak may be crowned with eternal snows. In ascending such a range we pass through the same gradations of climate as occur between the equator and the pole, each with its peculiar type of vegetation, from the stately forest and rank luxuriance of the tropics to the stunted shrubs and mosses of the polar clime.

Mexico, according to Milner, is divided into three different levels, characterized by distinct forms of vegetation. The *Tierras Calientes*, or hot district, includes all the regions which lie between the sea-level and the height of 2000 feet. Its mean temperature is 77° Fah., and it abounds with bananas, sugar, indigo, and cotton. The *Tierras Templadas*, or temperate district, is included between the altitudes of 2000 and 5000 feet, and possesses a mean temperature varying from 68° to 70° Fah. Here the bread-

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38. What is the avalanche of the glacier? Give the illustrations. 39. What is an iceberg? How do icebergs originate? 40. What is remarked respecting the distribution of moisture?

What is the subject of Chapter Fourth? 1. What is climate? What are the influences that chiefly control it? 2. How are the temperature and humidity of any region modified? 3. Explain the influence of latitude. What is meant by excessive climates? What is said respecting the depth beneath the surface of the earth to which the solar heat penetrates? Give the instances. 4. Explain the influence of altitude above the sea-level. Give the illustrations.

grains are cultivated, and oaks and cypresses flourish. The *Tierras Frias*, or cold district, is situated between the altitudes of 5000 and 8000 feet, where the air is still genial; but above this limit the oaks disappear, and pines and spruces abound.

Amid the Pennine Alps the chestnut grows at no higher altitude than 2800 feet. On the summit of the Jungfrau, 12,872 feet above the sea, the only kind of vegetation found by Agassiz, Professor Forbes, and others, were fine species of lichens.

5. **Position and Direction of Mountain-Chains.**—When mountain-chains run in such directions as to arrest the prevailing winds, they exert a great influence on climate in respect to moisture. The Andes water the eastern slopes and pampas of South America, by condensing the vapors borne thither by the easterly trade-winds, while they render the narrow plain of Peru dry and sterile. The Himalayas, in like manner, do not permit the treasures of rain, borne inland by the southwest monsoon, to reach the high plains of Tartary, but turn them back to the lowlands of India, and render the former a barren desert.

If the Andes were along the Atlantic, the table-lands of Brazil and the endless plains of the Amazon, now teeming with the most luxuriant vegetation, would become a desert. If the Rocky Mountains were along the east coast of North America, and the plains of the Mississippi opened to the southwest winds of the Pacific, the climate would become softer and the land would be better watered.

Where the mountain-chains run in an easterly and westerly direction, the sunny slopes of the southern declivities have in general a more genial clime than the opposite side. "It is on this account," says Malte Brun, "that in the Valais we see the Alps on one side covered with eternal ice, while vineyards and orchards adorn the opposite hills." Thus, on the northern side of these ranges the vine flourishes no higher than 1800 feet above the sea, while it grows on the southern or Italian side at the height of 3240 feet.

6. **Table-Lands.**—Lofty plateaus exert a powerful influence in modifying climate. This is strikingly shown in the Himalayas. On the southern side the extreme limit of cultivation is 10,000 feet above the sea-level, and nothing but low shrubs grows at the height of 13,000 feet; but on the northern declivity, at the last-named altitude, fields of barley abound and flowers in rich profusion meet the eye, while a little below are extensive vineyards and groves of apricots. At the height of 1700 feet the ground is covered with the tamabush. The cause of this difference in climate is the vast and sandy table-land of Tartary, which at the height of 10,000 feet stretches out its immense expanses north of the Himalayas. The radiation of heat from this arid and elevated region, increased by the serenity of its atmosphere, mitigates the climate on the northern slopes of the Himalayas, and forces up the snow-line many thousand feet above its position on the southern side.

In the vicinity of the plateau of Bolivia the same result is seen; for the snow-line on the Bolivian Andes is 2000 feet higher than it is at the equator.

7. **Maritime and Inland Climates.**—As the ocean acquires and loses heat more slowly than the land, maritime climates are more uniform than continental; for, although a place on the sea-coast may have the same mean temperature as another in the interior, the range of the thermometer is not so great in the former as in the latter. On the sea-side, therefore, the winters are mild and the summers cool, while in the interior the winters are cold and the summers hot. Thus, at the North Cape, which has a littoral climate and possesses the same mean annual temperature of 32° Fah. as Irkoutsk, which has a continental climate, the mean temperature of summer is 43° Fah., and of winter 23° Fah., while at Irkoutsk the respective mean temperatures of summer and winter are 60° and 0° Fah. (zero). "This law," says Kaemtz, "prevails everywhere. The vegetation of maritime and inland countries is different on this account. On the coast of Devonshire the camellia japonica lives in the open air throughout the winter. Laurels, fig-trees, pomegranates, and myrtle, which cannot grow in the centre of France, flourish luxuriantly at Brest."

NORTH CAPE.

Maritime countries are also humid, the air in the vicinity of the sea being saturated with moisture; but interior climes are dry. On the eastern coast of Africa, rains are abundant from Cape Guardafui to the Cape of Good Hope, while the vast plateaus to the west are dry and barren.

8. **Prevailing Winds.**—The direction of winds, and the nature of the surface over which they blow, modify climate materially. A wind from the ocean is moist, and from the land dry, warm when it blows from a low to a high latitude, and cold when this condition is reversed. Exceptional cases occur from the presence of ice-clad mountains.

The southwesterly winds of the Atlantic, warm in themselves, but rendered still warmer by the Gulf Stream, soften the climate of Western Europe, and give it a temperature many degrees higher than those regions possess which are situated in the corresponding latitudes on the east coast of America. The southwesterly breezes of the Pacific give, in like manner, a higher temperature than is enjoyed on the eastern shores of Asia under the same parallels.

The winds from the Arctic Sea have a free course on the Western Hemisphere, sweeping in icy blasts over the vast northern plains stretching to the Polar Sea. They are deflected by the Rocky Mountains, and become the dry and cold northwesters so well known in the United States. Siberia has the same bleak exposure; while

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5. What is the effect of the position of mountain-chains on climate? Illustrate by the Andes and Himalayas. What is said of the Andes and Rocky Mountains? Show how the direction of the Alps affects the climate on the Italian side. 6. State what is said of the influence of table-lands, and give the illustrations. 7. Compare the climates of maritime and inland countries, and give the illustrations. 8. Describe the effect of winds on climate, and give the illustrations.

the mountains and high table-lands to the south arrest the genial southern breezes.

At Bagdad and Bushire, the hot winds from the Arabian desert raise the temperature at times to 125° Fah. When the Khamsin from the Sahara prevails in Egypt, it is like the blast from a furnace.

9. **Ocean-Currents.**—The effect of these has already been noticed. The mass of warm water borne northward by the Gulf Stream softens the climate of the Atlantic States and that of all Western Europe. The same effect is produced along the eastern coast of Asia, at the Aleutian Isles, and on the shores of North-western America. The Antarctic current tempers the hot climes of Peru, and the Arctic stream moderates the burning heat of Central America.

10. **Nature of the Soil.**—A sandy and porous soil, which suffers the rain to sink through it, becomes drier and more intensely heated than clayey soils which retain the moisture. A rocky region is also drier than a low, alluvial tract.

11. **Cultivation.**—The climate of any country may be regarded on the whole as unchangeable, since there is no reason for believing that the general temperature of the earth has suffered any perceptible alteration since the earliest historic era, and the mean temperature of a country remains the same. Nevertheless, slight seasonal changes have been made by the labors of man.

It has been proved by observations that beneath the shades of forests, twelve inches below the surface of the earth, the temperature is 10° Fah. colder during the summer than it is at the same depth in the contiguous open plain, while during the winter it is the same in both situations.

In countries covered by dense forests the winters are longer and more uniform in temperature than in dry, cultivated regions, and in summer the mean temperature of the latter is higher than that of the former. When the woods are levelled and the surface of the earth exposed to the warmth and light of the sun, the summer becomes longer, and the winter less uniform in temperature. The climate of Western Europe is said to have been thus ameliorated; though according to Arago the climate of France has not altered since the century before the Christian era. By comparing the times of the ripening of plants and the periods of the vintage and harvest, as described by Roman writers, with the present times of vintage and harvest in the same localities, M. Dureas has arrived at the conclusion that the climate of Italy has not varied since the time of Cato the Censor, 147 years before Christ.

In reference to New England, Williamson remarks, "When our ancestors came to New England, the seasons and weather were uniform and regular. Autumn began with September, and the winter set in about the end of November, continuing till the end of February, when the spring began, and advanced without sudden fluctuations in temperature. The summer lasted but six weeks, and was insufferably hot. Now the seasons are totally altered, and the weather is far more changeable: the autumn begins and ends later, and the winter does not set in in its severity before the end of December."

The clearing of forests may be carried too far; for a country may be so denuded as to suffer from droughts by the drying up of brooks and water-courses.

12. **Miasma.**—The healthiness of many regions is materially affected by the noxious exhalations of the soil. This is especially the case on the low and humid coasts of tropical countries exposed to the intensest heat of the sun. Here, from the rank and decaying vegetation, and from the stagnant waters of the lagoons, rises the miasma, which fills the air with the seeds of pestilence and death. Such is the case on the equatorial shores of Africa, and on those of Guiana, whose climates are so fatal to the European races.

The Campagna of Rome, once the garden of Italy, but now desolate and filled with sluggish waters, has become unhealthy from the malaria that infects its atmosphere; and the inhabitants retreat to the higher ground as the sickly season approaches. When the soil of the primeval forests and of the prairies is first broken up and exposed to the sun, miasma prevails, which produces remittent and intermittent fevers.

ISOTHERMALS.

13. If lines are supposed to be drawn in the Northern and Southern Hemispheres through those places which have the same mean annual temperature, they are called isothermals,—from the Greek words *isos*, "equal," and *thermos*, "warm." On account of the great differences in the distribution of the solar heat from the equator to the poles, it might naturally be supposed that the isothermal lines would be nearly coincident with the parallels of latitude; but this is not the case; for the various modifying influences which have just been discussed produce, by their combined effects, wide departures from the parallels, and the isothermal lines encircle the earth in undulating curves.

Humboldt was the first to represent on charts these lines of equal temperature, thus showing at a glance the distribution of heat throughout the world. Such charts are termed *isothermal charts.* By inspecting the accompanying Meteorological Map, the striking deviation of the isothermals from the parallels of latitude will at once be seen.

It is a fact well deserving of notice that the isothermal curves extend farther to the north on the western coasts of the two great continents than on the eastern.

The *warm equator*, or isothermal of greatest heat, is also found sweeping far to the north of the geographical equator. The causes of these deviations have already been explained.

According to Sir David Brewster, the geographical north pole of the earth is not the coldest region in the Northern Hemisphere. The two places of most intense cold are found in about the 80th degree of north latitude, one being in America not far from the meridian of 100° west longitude, and the other in Siberia in about 95° east longitude. The mean annual temperature of the former is estimated by Dr. Brewster to be 3½° below zero, while that of the latter is 1° above zero. The mean annual temperature of the north pole he computes to be 5° above zero; but Arago, on the supposition that land extends to the north pole, considers its temperature to be much lower.

When Dr. Kane reached the highest latitude he could attain, during the Arctic summer, he observed continually flocks of sea-birds winging their way still farther to the north,—leading him to believe that the temperature was milder in the latitudes beyond him, and that the pole was surrounded by an iceless sea, such as was beheld by his companion Morton.

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9. How do ocean-currents affect climate? 10. What is the influence of the nature of the soil in this respect? 11. Do the mean temperatures of countries change? State the influence arising from cultivation. What views are entertained as regards a change of climate in Europe? What changes have taken place in New England? Is it a benefit to a country to be entirely deprived of its forests? 12. State the effects of miasma on climate. Where is this noxious influence chiefly found? Give the case mentioned. 13. What are isothermals? Do they coincide with the parallels of latitude? What is remarked of the isothermals of the western coasts of the two great continents? What is said respecting the warm equator? What views have been entertained in respect to the coldest places in the Northern Hemisphere? Where are the two coldest localities situated? What are their respective temperatures? What were the views of Dr. Kane?

14. **Zones of Climate.**—Certain important isothermal lines may be regarded as dividing the surface of the globe into five zones of climate,—characterized as *hot*, *warm*, *temperate*, *cold*, and *frigid*.

KANE'S OPEN SEA.

The *hot zone* is bounded on the north and south by the isothermal of 79°, and includes the northern part of South America, the middle of Africa, the peninsulas of India, and the Indian Archipelago. Here, wherever moisture abounds, a rank and luxuriant vegetation clothes the earth; but where it fails, nothing meets the eye but vast and sandy deserts, glowing with intense heat. Within this zone no snow or frost is found at the sea-level.

Beyond this is the *warm zone*, extending to the isothermal of 68° Fah., and comprising, in the Northern Hemisphere, Mexico, the Gulf States, the northern parts of Africa, Egypt, Arabia, Persia, Upper India, the Birmese Empire, and Southern China. It possesses the characteristics of the hot zone, burning deserts alternating with a rich exuberance of vegetation wherever moisture abounds. In the Southern Hemisphere it includes the central portions of South America, Southern Africa, and Central Australia.

Next succeeds the *temperate zone*, bounded by the isothermals of 68° and 32° Fah. In the Northern Hemisphere it comprehends a vast area of land, including a great part of North America, the whole of Europe, and Central Asia. Within it, tropical vegetation disappears and the bread-grains flourish. Man here attains his highest intellectual, social, moral, and religious development; and this region is, consequently, the abode of the dominant races of the earth. In the Southern Hemisphere the temperate zone includes, in respect to land, the southern portion of South America, the Cape of Good Hope, and Southern Australia.

Beyond this belt lies the *cold zone*, extending to the isothermal of 10° Fah., and in the north comprising within its boundaries Northwest America, the vast region around Hudson Bay, and most of Greenland and Siberia. Here the ground, at varying depths, is constantly frozen; but the powerful heat of the brief summer suffices to thaw and warm the surface of the soil to such an extent that wheat, rye, and barley grow and ripen. Evergreens are the prevailing type of trees.

The *frigid zone* of climate extends beyond the isothermal of 10° Fah., and contains within its limits in the Northern Hemisphere the region lying north of Hudson Bay, together with a portion of Northern Asia. Here ice and cold reign supreme. Evergreens are found near the southern border of this tract; but mosses and lichens cover the expanse of mingled earth and ice which stretches towards the pole. Man, battling with cold, is here dwarfed and undeveloped, all his energies being employed to provide for his lowest physical wants.

Taking a general view in respect to climate, we find that North America, Europe, and Asia possess, on the whole, a temperate climate, while Africa, South America, and the greater portion of Australia may be regarded as having a tropical climate.

CHAPTER V.

OPTICAL AND LUMINOUS PHENOMENA.

1. A RAY of solar light consists mainly of seven colored rays, blended together, which may be separated by various methods. First, by *refraction*, when it is turned from its course by passing from one medium into another of a different density,—as is shown by suffering a solar ray to pass through a solid triangular piece of transparent glass, called a prism. The light is then decomposed into seven principal colors,—viz.: *red*, *orange*, *yellow*, *green*, *indigo*, *blue*, and *violet*; the red being most refracted, and the violet least. These colors are called the *prismatic colors*.

Light is also decomposed by *absorption*. A red rose receiving the white light of the sun absorbs all the prismatic colors except the compound red, which it reflects, and by which it is visible; and so of other colored objects. A white object, as a water-lily, *reflects* each of the prismatic colors in due proportion; while a black object, as charcoal, *absorbs* a portion of all of them. When the sunlight passes across the edge of a body, it is also broken up into the different-colored rays by *diffraction*. In these and other methods the solar beam is separated into its wondrous colors, which, blended together in varied proportions, form that countless variety of hues that adorn the earth with its manifold beauty. The land glows with the splendid and delicate tints of bloom and flower, its autumnal forests wave in crimson and gold, and through the tropic woods flash birds of brilliant and matchless plumage; in waves of green and blue the ocean breaks on its shores, strewed with shells of beauteous hues; while the azure vault of heaven is spanned by the gorgeous rainbow and is radiant with the rich colors of the morning and evening clouds.

OPTICAL PHENOMENA.

2. The optical phenomena of the atmosphere are the *Rainbow*, the *Colors of the Sky and Clouds*, the *Mirage*, *Aerial Shadows*, *Halos*, and *Coronas*.

3. **Rainbow.**—The rainbow is that arch of colored light which is seen when rain is falling and the sun shining at the same time. It is beheld in a direction opposite to the sun; and an imaginary line drawn from the sun through the eye of the spectator towards the bow strikes its centre. A different bow is, therefore, seen by each spectator.

When the bow is complete, it consists of two arches of colored

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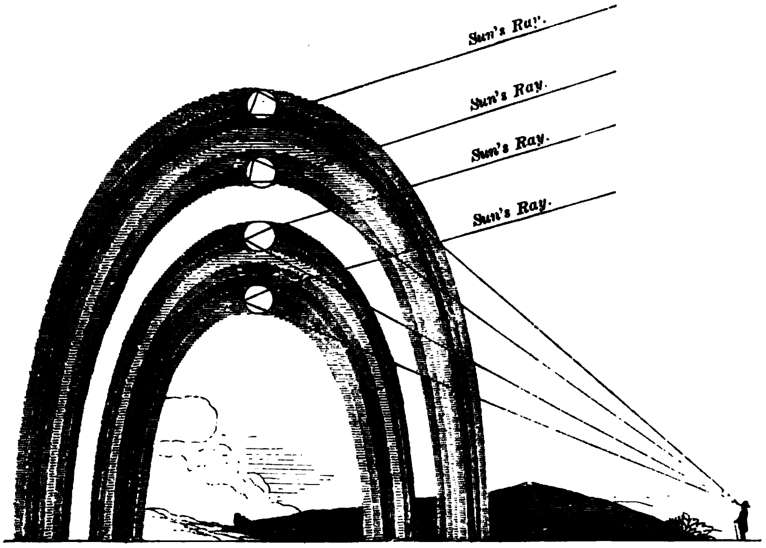
14. What do we understand by zones of climate? How are they characterized? Give the limits of the respective zones, and describe them.

What is the subject of Chapter Fifth? 1. Of how many colors is a ray of solar light composed? How is it decomposed? Whence arise the colors of natural objects? 2. What are the optical phenomena of the atmosphere? 3. Describe the rainbow.

light,—the inner or primary, and the outer or secondary bow,—each composed of the seven prismatic colors. In the primary bow the red is uppermost, and the violet lowest; in the secondary, the position of the colors is reversed.

The phenomenon of the rainbow is thus explained. When a ray of the sun strikes a falling drop of rain, a portion of the light enters the drop, is decomposed into the prismatic colors, is then reflected successively from the surface of the drop, and at last is refracted again into the atmosphere. The rays of the primary bow come to the eye after *one reflection* and *two refractions;* those of the secondary, after *two reflections* and *two refractions.* A tertiary bow, formed by *two refractions* and *three reflections,* is also possible; but as it is situated near the sun, and a great amount of light is lost by so many reflections and refractions, it is extremely faint, and is rarely seen.



RAINBOW,—PRIMARY AND SECONDARY BOWS.

Supernumerary bows, consisting mostly of green and red arches, are at times beheld on the violet side of the primary bow. Four such bows were beheld by Dr. Brewster on the 29th of July, 1813; and two were seen by the author, at Hartford, Connecticut, on the 5th of August, 1847, at sunset, extending throughout the whole semicircular arch.

The circular form of the bow is due to the fact that the red light, for instance, which comes from the rain-drops to the eye of the observer, *must,* in order to be seen, ever make the same angle around the imaginary line proceeding from the sun through the eye of the spectator to the region of the sky where the bow is observed. The red light, therefore, must form a circular arch around this line; and so of all the other colors of the bow. Open a pair of tongs, and, keeping the legs the same distance apart, turn one leg around the other: the latter will represent the imaginary line, the former the direction in which any colored ray comes to the eye, and the circle described by the revolving leg, a colored arch of the bow.

The magnitude of the bow depends upon the position of the sun in regard to the spectator. When the latter is upon a plain, as the ocean, and the sun is in the horizon, a perfect semi-circumference is beheld; but the bow exhibits a smaller part of the circumference as the sun is higher in the heavens. When the latter is at the altitude of about 42°, only the top of the primary bow is seen. If the spectator is upon a lofty mountain, he beholds a bow somewhat greater than a semi-circumference.

Beautiful bows are beheld in the spray that rises from cataracts. The falls of Tequendama, in Bogota, are spanned by rainbows; and the clouds of mist that ascend from Niagara are resplendent with arches of colored light.

4. **Lunar and other Bows.**—These are formed in the same way as the preceding; but, on account of the feeble light of the moon, they are quite rare and the colors indistinct. Tyerman and Bennet, on the 11th of September, 1821, beheld at sea a remarkable phenomenon of this kind. It appeared as a complete semicircle, and was attended for a few moments with a secondary arch: the prevailing colors were green and orange, but were faint compared with those of the solar bow.

5. **Colors of the Atmosphere and Clouds.**—The rays of the sun, on their way to the earth, pass through the atmosphere, whose strata differ in density, and they are consequently refracted and decomposed, as when they traverse a prism. The red and orange rays are least refracted, but the blue and violet deviate most from their original directions, and are, consequently, dispersed throughout the atmosphere, and, being reflected from its particles, impart to the sky its azure hue.

The intensity of the blue tint of the atmosphere increases from the horizon to the zenith; for the light vapors that settle down towards the earth and mingle with the atmosphere lessen its brilliancy. For a similar reason, the sky in the temperate regions has a paler tint than in the tropics, where the vapors, under the high temperature that there prevails, are perfectly absorbed, and the heavens glow with the richest azure, as in Italy and California. In the Arctic climes, where the atmosphere is rendered pure by the precipitation of the vapor, the same result occurs; and the skies of Spitzbergen rival at times, in their deep azure, those of the tropics.

As we gradually ascend above the sea-level, and leave the vapors below, the intensity of the color of the sky increases, until at very lofty heights the heavens appear black; for then the greater portion of the atmosphere is below the observer, and there is but little above to reflect the blue light. Upon the Alps, De Saussure noticed the vivid blue of the sky; and at Zinchin, amid the Himalayas, 16,000 feet above the sea, the sky appeared to Moorcroft of a black color.

If we look at a lamp through a thin piece of porcelain, it appears of a red color; because the porcelain has absorbed all the colors in the light that comes from the lamp, except the red. In like manner, at dawn and sunset, the solar beams, traversing the misty atmosphere and the clouds that float within it, lose by absorption all their colored rays, except the most refrangible, as the red and orange. These, penetrating the clouds, are reflected from their atoms, and cause them to glow with their own rich hues.

On this account, the most common colors of clouds are red, orange, and yellow, with their various shades; but at times they are radiant with many other hues, and in California and India the sky is often adorned with green and violet.

6. **Mirage.**—This name is given to that optical phenomenon in which objects are seen both above and below their true positions. Ships are beheld high in the air; troops of soldiers march in the clouds; long lines of coast are raised above the level of the sea; the

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How is the rainbow caused? What are supernumerary bows? How is the circular form of the bow explained? What is said respecting its magnitude? Are bows seen over cataracts? Give the instances. 4. What are lunar bows? Are they brilliant? Describe the one mentioned. 5. Explain the cause of the blue color of the atmosphere. State what is said of its variations in brilliancy. How are they caused? and give the illustrations. How are the colors of clouds accounted for? What are the most usual colors, and why? 6. What is the mirage?

fiery desert is changed to a cool and tranquil lake, shaded by verdant groves; and cities, with their splendid array of palaces, towers, and arches, are mirrored in the quiet waters of the adjacent sea.

Numerous instances of this phenomenon are on record. When Captain Scoresby navigated the Arctic seas, in 1822, he recognized his father's ship, the Fame, by its inverted image in the air; though it was afterwards found to have been at that time thirty miles distant, and seventeen miles beyond the horizon.

A singular mirage is mentioned by Rozel, which he witnessed in Algeria, on the 27th of June, 1830. During a review of the French troops, as he looked along the line of soldiers, he beheld another line above it, exactly similar,—more faint, but perfectly distinct. But the most extraordinary spectacle of this kind is the celebrated Fata Morgana, which is seen at Reggio, in the Strait of Messina. Under favorable circumstances, a spectator there beholds, on the surface of the sea, an image of the city, with its towers, palaces, and terraced heights, distinctly mirrored on the waters, and also hanging in the air, when a veil of mist floats above them.

FATA MORGANA, AT REGGIO.

The mirage of the desert—called by the Arabs *serab*, or "deceitful"—frequently presents such a perfect illusion that it is difficult to distinguish the real object. During the march of the French army under Bonaparte over the sandy plains of Egypt, the villages appeared to be surrounded by an extensive lake bordered by verdant fields, while beneath each village was an inverted image of the same.

The Hon. Mr. Elphinstone, in his account of his embassy to Cabul, thus describes this phenomenon:—"We had made a march of thirty miles to Moujgur: the heat of the afternoon was intense, and we halted, as usual, on the naked plain, to take refreshments. Toward evening many persons were astonished at the appearance of a long lake enclosing several little islands. Notwithstanding the well-known nature of the country, many were positive it was a lake, and one of the surveyors took the bearings of it."

The cause of the mirage is explained as follows. When the strata of the atmosphere differ in temperature, they differ also in density, and the rays of light which then pass through or are reflected from them are consequently changed in *direction*. On this account, an object will appear out of its true position, since we always see it in the *last* direction in which the rays that proceed from it come to the eye. Thus, the blade of an oar in the water appears above its true position, and standing before a mirror we see ourselves apparently behind it.

MIRAGE OF THE DESERT.

In the polar seas, the temperature of the air directly above the water increases, at times, with the height. Rays of light proceeding upwards from a ship will, in this case, be refracted downwards more and more, until they are at length reflected to the earth, and may reach the eye of an observer far distant from the ship. An image of the vessel may then be seen in the air, inverted, if the rays cross each other, as in the case of the mirage observed by Scoresby.

In the desert the conditions of temperature and density are frequently reversed, and the rays of light proceeding downwards from objects are reflected upwards, and form images below them. Mirages are also caused by reflection, as the Fata Morgana, which is attributed to the reflection of the rays of light from the surfaces of the sea and of the vapor.

7. **Aerial Shadows.**—The shadows of objects, magnified by reflection, are sometimes seen projected upon the clouds and sky. On the 14th of August, 1849, as a party were standing in front of the Mountain House, at Catskill, New York, each person beheld his own shadow, of huge dimensions, cast on the clouds before him. In Perthshire, in Scotland, north of the village of Comrie, there stands upon the lofty hill of Dunmore an obelisk seventy or eighty feet high. On the 21st of August, 1820, a perfect shadow of this hill and obelisk was distinctly projected on the northern sky, at the distance of two miles. This aerial picture was visible for the space of ten minutes. The colossal phantom of the Brocken, so famous in German legends, is an appearance of the same kind.

8. **Halos.**—Halos are circles and combinations of circles, of prismatic colors, surrounding the sun and moon,—the violet being the outer color, and the red the inner. The breadth of the ordinary halo is about half the distance from the horizon to the zenith, and the extraordinary halo has twice this extent. At times this phenomenon is quite complicated, and the ordinary and extraordinary

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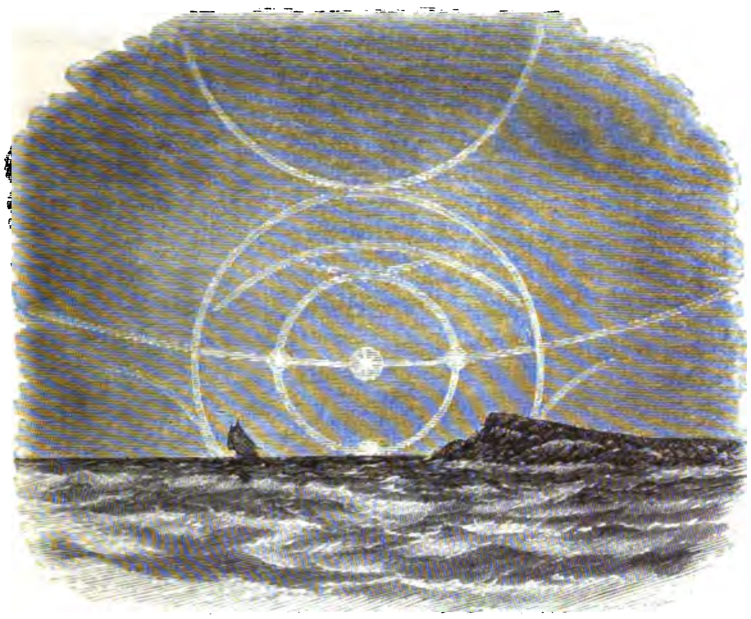
Give the instance of images above the object. What is the mirage of the desert? Describe its phenomena. Give the illustrations. Explain its cause. 7. Describe aerial shadows, and give instances. 8. What are halos? What combinations sometimes occur? How are they caused?

halos are then beheld simultaneously, while other colored circles are seen touching and intersecting them. Wherever the circles cross each other, the light accumulates, and brighter spots occur, termed ***parhelia*** and *paraselenæ*, or mock suns and moons.



PARHELIA.

We have seen that the light cirrus clouds probably consist of ice-crystals; and halos can be satisfactorily explained by supposing a stratum of such crystals floating before the sun, and that the rays of the latter, in their passage to the earth, are refracted and decomposed by traversing these minute prisms. If we gaze at the moon, or a street-lamp, through the frost-work on a pane of glass, a halo is seen around those objects, caused by the refraction of their light in passing through these delicate ice-prisms. An analogous phenomenon is presented at rare intervals when the sun is near the horizon. It is an upright column of light, of great beauty, tinged with prismatic hues; and with it are sometimes seen images of the sun, which rival the true sun in splendor.

At St. Paul, Minnesota, there was seen in December, 1850, from sunrise to sunset, the extraordinary spectacle of the sun attended by two images of such intense brightness that the three orbs appeared to be equally brilliant.

9. **Coronas.**—Coronas, like halos, are circles of prismatic light surrounding the sun and moon; but they differ from them in several particulars, being much smaller and less complicated, while the order of the colors is reversed.

Coronas are seen when light vapors partially veil the sun and moon: they are more frequently beheld encircling the latter, for the eye is usually too much dazzled by the brightness of the solar light to detect the faint hues of the corona. It is very rarely the case that the corona displays all the prismatic tints.

Coronas are caused by the diffraction and decomposition of the solar or lunar rays as they pass between the globules of vapor that form the haze which veils those luminaries. Anthelia, or coronas opposite to the sun, are frequently beheld when the shadow of the observer is cast upon a mist or cloud. Some of these phenomena are exceedingly beautiful. Scoresby beheld coronas in the polar regions, on the 23d of July, 1821, when no less than four concentric prismatic circles surrounded the shadow of the head of the observer. A similar phenomenon was seen by Mr. Green, the aeronaut, at the height of more than two miles, the shadow of the balloon on the upper surface of the clouds being surrounded by three circles glowing with all the hues of the rainbow. To explain the cause of anthelia, we have simply to suppose that the rays of light, after being diffracted, are also reflected from the surfaces of the globules of vapor.

Luminous Phenomena.

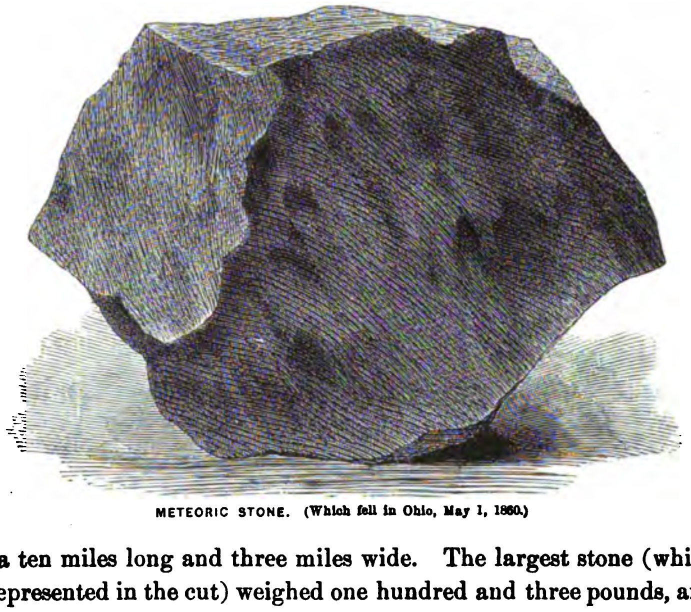
Under this class may be included *Meteorites*, *Shooting Stars*, and the *Ignis-Fatuus*.

10. **Meteorites.**—Meteorites are solid fiery bodies, which sweep through the atmosphere with great velocity, and are commonly attended by a luminous train. Explosions generally occur, by which fragments are detached and descend to the earth. These are called *meteoric stones*.

It appears, from the researches of men of science, that these phenomena have been constantly taking place from the earliest times, in all parts of the globe, and that scarcely a year passes without their occurrence.

According to Livy, a shower of stones fell upon Mount Alba in the reign of Tullus Hostilius, about 650 years before Christ; and another is mentioned by Cæsar that descended at Acilla, in Africa, 600 years afterwards. Many writers describe the appearance of a luminous meteorite that passed near Milan in the year 1510: the phenomenon was attended by a fall of stones in number about twelve hundred, two of which weighed respectively sixty and one hundred and twenty pounds.

On the 1st of May, 1860, a meteorite passed over Northwestern Virginia and Southeastern Ohio. It appeared as a blazing ball of fire, was followed by a brilliant train of light, and exploded with a loud noise, which was heard over an area 150 miles broad. At New Concord, in Muskingum county, a loud report was first heard, like that of a cannon, which was followed, at intervals of a few seconds, by *twenty-three* distinct detonations, when the sounds became blended together and resembled the roar of a railway-train. After these explosions, a large number of stony fragments fell throughout an area ten miles long and three miles wide. The largest stone (which is represented in the cut) weighed one hundred and three pounds, and penetrated into the earth between two and three feet. It is now in



METEORIC STONE. (Which fell in Ohio, May 1, 1860.)

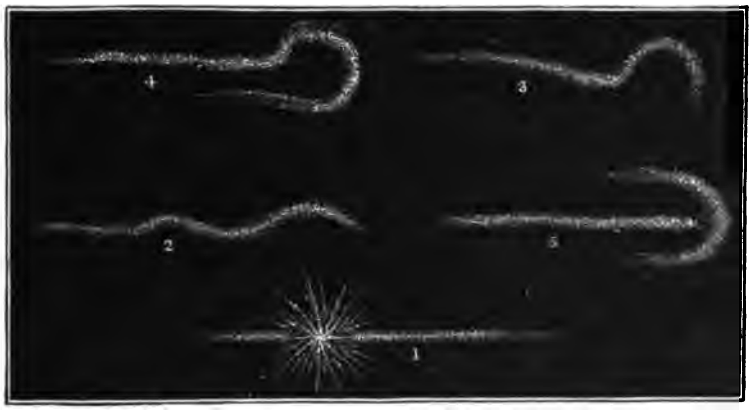
What analogous phenomenon is mentioned? Give the illustration. 9. What are coronas? How do they differ from halos? When are they seen? How are they caused? Describe anthelia. Give instances. How do they originate?

10. What are meteorites? What are the fragments called? What appears from the researches of scientific men? What instances of the fall of meteorites are mentioned? Of what do meteoric stones sometimes consist?

the cabinet of Marietta College. The height of the meteorite above the earth, according to the computations of Professor Evans, was about forty miles, and its diameter was nearly two thousand feet.

The fragments that fall from meteorites are sometimes composed almost entirely of malleable iron. A large mass of this kind, found in Texas, and weighing 1635 pounds, is now in the cabinet of Yale College.

Meteoric stones have the same general appearance, being coated with a black, shining crust, and when subjected to analysis they are found to consist of the same elementary substances.



METEOR OF SEPTEMBER 30, 1850.

11. **Shooting Stars.**—Shooting stars, or meteors, are luminous bodies that are seen darting noiselessly through the sky, followed by a bright train, and at times attended by dazzling coruscations. They differ from meteorites in being usually unaccompanied by explosions; and no portion of a meteor has ever been known to reach the earth. Solitary shooting stars are of common occurrence; but there are certain times in the year, as the 9th and 10th of August and the 12th and 13th of November, when they are very numerous, and hundreds may be seen from a single point of observation, flashing in splendor through the heavens. Displays of surpassing grandeur have also been noticed, which it is supposed recur after intervals of about thirty-three years.

On the 12th of November, 1799, Humboldt and Bonpland beheld, at Cumana, in South America, thousands of falling stars, which illumined the sky for the space of four hours. Their flight was marked by a luminous path, which continued visible for the space of about eight seconds. A few of these bodies exploded, but nearly all disappeared without scintillation.

On the 12th and 13th of November, 1833, another star-shower occurred, which was still more magnificent. It was beheld from Canada to Jamaica, and from the 61st to the 150th degree of west longitude, and for the space of seven hours the heavens blazed with an incessant discharge of fiery meteors, many of them equalling in size and brilliancy the largest stars. It was estimated that at this time no less than 240,000 meteors fell.

The recurrence of this extraordinary phenomenon in 1866 was confidently predicted by meteorologists. In America the display of meteors was not remarkable; but magnificent star-showers were beheld in Scotland and Syria on the morning of the 14th of November.

The apparent size of these bodies is at times very great; for during the November shower of 1833 an immense luminous globe, which seemed as large as the full moon, swept across the sky. Shooting stars are usually visible but for a few seconds; but instances have occurred when they have continued in sight for more than an hour. Such was the meteor beheld at the Harvard Observatory on the night of the 30th of September, 1850, which was first seen by the famous vocalist Jenny Lind. It appeared a little before nine o'clock, and, passing through various changes, continued visible until after ten o'clock. The preceding cut represents the successive transformations of this meteor, beginning with figure 1.

Various theories have been proposed to account for the origin of meteorites and shooting stars. Some philosophers suppose meteorites to be thrown from the moon, and others from volcanoes; while according to another hypothesis they are simply bodies revolving, like the moon, around the earth. The meteoric showers of November are attributed by Professor Olmsted to bodies of this kind. Meteorologists, however, are now inclined to adopt the view of Chladni, according to whose theory millions of small bodies exist, which revolve around the sun in the same manner as the planets. They are not uniformly diffused through space, but in some regions are scattered, and in others are grouped together in vast numbers, constituting rings about the sun, many of which cross the orbit of the earth. Interspersed with these small bodies are solid masses of considerable size.

The various meteoric phenomena are supposed to arise as follows:—

When the earth, in its annual progress, passes through the regions where these bodies are thinly diffused, they are attracted by the earth, and descend through the atmosphere with such velocity that they ignite, and are consumed. Under these circumstances, the ordinary phenomenon of shooting stars occurs. When the earth traverses the densely-crowded zones, star-showers are beheld; and should any of the large solid masses enter the atmosphere of the earth, they also become inflamed, and the fiery meteorite rushes through the sky.

According to Professor Newton, of Yale College, the August ring contains no less than 300,000,000,000,000 meteoric bodies.

12. **Ignis-Fatuus.**—The Ignis-Fatuus, commonly called Jack-o'-Lantern, or Will-of-the-Wisp, is a flickering, movable light, which is seen hovering over burying-grounds, battle-fields, and low meadows and marshes, and is generally of a pale-red or bluish color.

IGNIS-FATUUS.

What is said of their general appearance and constitution? 11. What are shooting stars? Are solitary shooting stars frequent? What is said of the annual display? When do extraordinary star-showers occur? Mention what is said respecting them. Give the various theories respecting the origin of meteorites and shooting stars. How does Professor Olmsted account for the November meteors? State the theory of Chladni. Of how many meteoric bodies is the August ring supposed to consist? 12. What is the Ignis-Fatuus? Give the illustration.

In May, 1821, a very fine display of the ignis-fatuus was witnessed by M. Doe, in the marsh of Chapelle-aux-Planches, in France. It resembled a pyramid of pale red light, ten or twelve feet high, and was so bright that a person could read by it; but it had no heat.

The ignis-fatuus has been supposed to arise from the inflammable gas caused by the decay of animal and vegetable substances, and which ignites spontaneously when it comes in contact with the atmosphere; but, inasmuch as it is generally unattended by heat, it is to be regarded rather as a simple phosphorescence.

13. **Relation of the Sunlight to the Atmosphere and Natural Objects.**—If neither the atmosphere and its vapors, nor the various objects of nature, possessed the power of decomposing and diffusing the solar rays, the sky would lose its azure, its gorgeous clouds and arches, and the earth would be divested of her robes of beauty. Nor is this all; for without the atmosphere "the sunshine would burst upon us in a moment, and fail us as soon, removing us in an instant from midnight darkness to insufferable light. We should have no twilight to soften and beautify the landscape, no clouds to shade us from the scorching heat."

CHAPTER VI.

ELECTRICAL PHENOMENA.

1. **Electricity.**—Electricity is classed with those universal and powerful agencies of whose nature we are ignorant, and which are known only by their effects. It is seen in one of its simplest developments when sparks are elicited by the rubbing of a glass tube with a piece of silk, and is displayed in the grandest forms when the vivid lightnings illumine the darkness of the storm.

Electricity exists in two states, vitreous and resinous, or *positive* and *negative*, which are developed simultaneously: thus, when it is produced by friction, the rubber has one kind of electricity, and the body rubbed the other. Bodies which are similarly electrified repel each other, but when differently electrified attract.

If two bodies highly charged with electricity, one negatively and the other positively, are free to move, they approach one another, and at length, with a flash and a report, each body imparts to the other a portion of its own electricity, receiving from the other an equal amount of the opposite kind. An electrified body, in proximity with one that is not electrified, induces on the nearest side of the latter that kind of electricity which is opposite to its own. This process of developing electricity is called *induction.*

Substances like *metals, water, fresh vegetation,* and *living animals,* which transmit electricity with facility, are termed conductors; those through which it passes with difficulty, as *gutta-percha, lac, glass, silk,* and *dry air,* are called non-conductors, or insulators. The atmosphere when dry is an exceedingly good non-conductor.

Electricity pervades all bodies; but in their natural state the two kinds of electricity neutralize each other, and its presence is not, therefore, manifested.

2. **Origin.—Atmospheric Electricity.**—No mechanical or chemical change can occur without the development of electricity; and in the great laboratory of the globe it is produced to an immense extent. Friction, arising from every motion, is one source of atmospheric electricity. The ripple of the tiniest brook, the long line of breakers that thunder on the shore, the winds that chafe the mountains and rock the forests, and the fury of the ocean, all produce electricity.

Evaporation is another cause, and one which is most energetic; for a vast amount of vapor is constantly rising from sea and land and filling the recesses of the atmosphere. When this vapor is condensed, and is restored to the earth in the form of rain, fog, dew, snow, and hail, electricity is again developed; and in condensation we recognize a third source of atmospherical electricity. Its amount is still further increased by the processes of combustion and vegetation; for wherever a fire is kindled, or a plant springs from the soil, electricity is generated. The electricity produced in a day from a field six hundred square feet in extent, and in full vegetation, is estimated by Pouillet to be sufficient to charge a powerful battery.

3. **Electrical Condition of the Atmosphere.**—It appears, from numerous experiments, that the electricity of the atmosphere in its ordinary state is *positive,* and that it increases in intensity with the altitude. It is, however, subject to great and rapid changes in this respect. From the observations of Schübler of Stuttgard, it has been shown that electricity is more intense during storms than in fair weather, and often changes suddenly at these times from positive to negative, and the reverse; but in cloudy weather unattended with storms, it is positive. The electricity of the atmosphere is stronger in winter than in summer, and twice in the day it also changes in strength, being most intense about eight A.M. and eight P.M., and weakest near sunrise and a little before sunset. The earth is charged with negative electricity.

4. **Thunder-Storms.**—When large bodies of air, differing in temperature and charged with humidity, are rapidly combined, as by the action of winds, a sudden and powerful condensation occurs, and electricity is developed on a vast scale. As the clouds form and the rain descends, it plays in vivid lightnings amid the darkness of the storm, followed by the roll and crash of the thunder.

As the combinations that produce the storm decrease in energy from the equator to the poles, thunder-storms are less violent and frequent in the high than in the low latitudes. Thus, they are very rare in Greenland, according to Gesecke; while sixty occur yearly in Calcutta.

During the Mexican War, an incident befell a detachment of soldiers, on their march from Mexico to Vera Cruz, which strikingly illustrates the intensity of the tropical thunder-storm. It is thus related by the surgeon of the regiment:—

"A singular occurrence took place near the end of our first day's march from Puebla. The clouds gathered in the mountains on our right, and the distant thunder warned us that the usual afternoon's rain would soon be upon us. I was riding in the rear of the troops with another officer, when, at the distance of half a mile from our camp, the storm burst suddenly upon us, the lightning blazing down in vivid columns followed quickly by sharp reports of thunder. I felt a sudden bewilderment, and then lost all consciousness. I was aroused from my stupor by some officers, who asked what could be

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What is said respecting the origin of the ignis-fatuus? 13. What is said of the relation of the sunlight to the atmosphere and natural objects?

What is the subject of Chapter VI.? 1. What is said of electricity? Describe the different states of electricity, how they arise, and the effects of electrified bodies on each other. What is induction? What are conductors and non-conductors? Where is electricity found? 2. State what is said in regard to its origin and extent. Mention the chief sources of atmospheric electricity, and state what is said respecting them. 3. State what is said of the electrical condition of the atmosphere. With what kind of electricity is the earth charged? 4. Explain the origin of thunder-storms. Where are thunder-storms most frequent and violent? Give proofs respecting their frequency. Give an account of a thunder-storm near Puebla.

done for myself and the soldiers. I turned my eyes upon the regiment, and beheld a most appalling sight. One entire company was stricken to the earth, their arms lying in irregular heaps beside them. The scene appeared like that of a battle-field that had been raked by the enemy's batteries. Very soon I was able to give directions to relieve the sufferers, and was rejoiced to find that most of them were only shocked by the electric fluid that had run along the ground."

5. **The Lightning-Stroke.**—When electricity is generated in the atmosphere, it accumulates on the surfaces of clouds that float within it, as the air itself is a non-conductor. Some clouds are charged negatively, and others positively; and if two clouds differently electrified gradually advance towards each other, they are mutually attracted, and the intensity of their respective electricities is increased. As they continue to approach, the electric attraction at length becomes so great that the resistance of the intervening air is overcome, and the two electricities combine in a flash of lightning, which is followed by thunder. The same interchange takes place between the earth and the clouds.

Arago divides lightning into three kinds,—*zigzag*, *ball*, and *sheet lightning*. Zigzag lightning is common: it appears like a broken chain, is sharply defined, and often forks or separates into distinct branches between the clouds and the earth. From the experiments of Arago, the velocity of zigzag lightning has been ascertained to be at least 250,000 miles per second.

Ball lightning is a rare phenomenon, in which the electricity is seen like a globe of fire, and advances with a slow motion. An instance of this kind was witnessed by Captain Home, of the ship Dyer, at 11.30 P.M. on the 14th of November, 1852, in 37° 40′ north latitude, 16° 57′ west longitude. The wind was then blowing from the southwest, and the weather squally, when a globe of fire about the size of a thirty-two-pound cannon-ball was seen coming from the northeast, which struck the foretopsail of the ship and burst with a report like that of a cannon.

Sheet lightning is most common, and happens when the flash expands and diffuses a glow of light over the clouds, rendering their outlines distinctly visible. The silent flashes of light that illumine the horizon for hours during the serene evenings of summer have received the name of *heat lightning*, and are regarded as the reflection of the lightnings of distant storms. It is evident, however, that sometimes during sultry weather, when the air is rarefied and humid and becomes an imperfect conductor, this phenomenon arises from the noiseless interchange of electricity between the atmosphere and the earth.

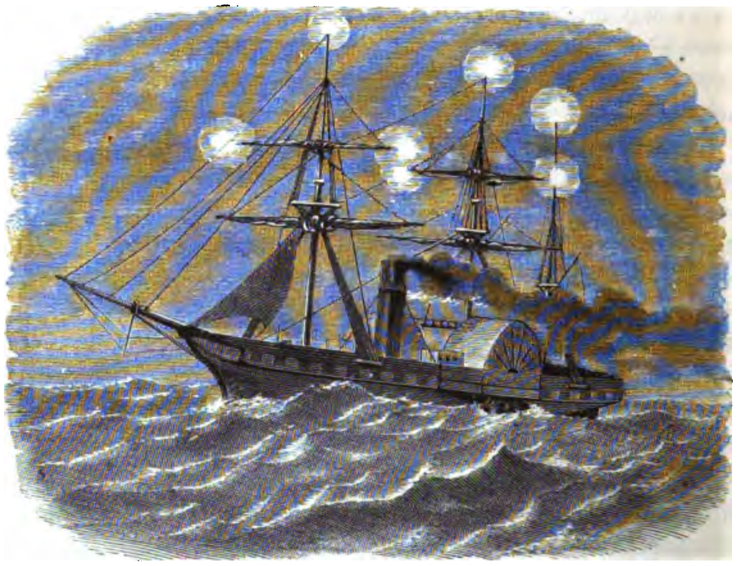
6. **Thunder.**—When the lightning-flash occurs, it produces, by its expansive force, a sudden and powerful displacement of the particles of the atmosphere along the line of its passage. Into this partial vacuum the air rushes back; and the thunder is regarded as the effect of the violence of the collapse. The rolling of thunder arises from reverberations, and also from the circumstance that the reports from different points in the path of the lightning reach the ear in succession. The thunder follows the lightning, because the velocity of light is 192,000 miles per second, while that of sound is only about 1142 feet per second. According to Petermann, the loudest thunder can scarcely be heard at the distance of ten miles.

7. **Effects of Lightning.**—Lightning destroys life, inflames combustibles, fuses metals, vitrifies sand, ruptures and displaces heavy bodies, and renders iron magnetic. A striking instance of its mechanical effect was displayed when St. Bride's Church, London, was struck, on the 18th of June, 1764. A stone weighing seventy-two pounds was then projected from the steeple one hundred and fifty feet in falling the distance of two hundred feet. The steeple was so greatly injured that eighty-five feet of it had to be rebuilt. In one place twelve hundred-weight of stone was thrown down.

8. **Electric Action of the Wires of the Telegraph.**—Atmospheric electricity affects the wires of telegraphs. The electricity developed during a snow-storm has been known to work the telegraphic machines; and in thunder-storms, violent explosions often occur not only when the wires are actually struck, but by the inductive action of a storm, without any transfer of electricity.

On the 10th of July, 1851, during a thunder-storm, one of the telegraphic offices in Hartford, Connecticut, appeared in a blaze of light. It was caused by electric sparks flashing rapidly from the wires, with reports like pistol-shots, and which were sufficiently intense to scorch the window-frames where the wires entered the office.

9. **St. Elmo's Fire.**—This name is given to those pale flames, attended at times by hissing noises, that tip the extremities of objects during a highly electric state of the atmosphere. It is a peculiarity of electricity that it seeks to escape by points; and when any portion of the surface of the earth is intensely electrified, the interchanges between the atmosphere and the earth are most energetic at the extremities of prominent objects, as the summits of mountains, the tops of masts, the points of spears, and the heads of persons.



ST. ELMO'S FIRE.

Cæsar relates that during the African war, in the month of February, a storm of hail occurred, in the second watch of the night, when the spears of the fifth legion appeared as if tipped with fire. In 1835, on the 9th of March, a fine display of this phenomenon was beheld on board the Royal William steam-ship, on her passage from London to Leith, during a storm of sleet and wind. Seven balls of fire were seen upon the masts and cross-trees. They continued visible for an hour, and appeared to the seamen who ascended the masts to examine them, to hiss like heated iron when plunged into water.

10. **Lightning-Rod.**—In 1752, Franklin made his celebrated

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5. How is the phenomenon of lightning accounted for? Mention the different kinds of lightning. What is said of the velocity of zigzag lightning? Describe each kind, and give an instance of ball lightning. What is heat lightning? 6. How is thunder caused? Whence arises the rolling of thunder? Why does thunder follow lightning? How far can the loudest thunder be heard? 7. Describe the effects of lightning. 8. Describe the action of electricity upon telegraphic wires. 9. Describe the phenomenon called St. Elmo's Fire. Give the instances mentioned.

electric experiment of drawing lightning from the clouds by the aid of a kite which was raised upon the approach of thunder-storms. By means of the lightning obtained in this manner, he performed all the common electrical experiments, thus proving the identity of lightning with electricity.

The invention of the lightning-rod was the fruit of this discovery. This instrument is simply a metallic rod erected upon buildings and the masts of ships. It should be pointed at the upper end, rise above the objects it is designed to protect, be continuous, and terminate below in water or moist earth. It affords protection from lightning because the electricity, in its passage between the clouds and the earth, is transmitted with greater facility through the rod than through the building or vessel on which it is erected. According to the rule of the French Institute, the lightning-rod protects a space around it to a distance equal to twice its height.

11. **The Aurora Borealis, or Northern Light.**—The Aurora is a luminous phenomenon, of great beauty, beheld in the northern sky. The same splendors are also seen in high southern latitudes, and receive the name of the Aurora Australis, or Southern light.

The aurora consists, when most brilliantly displayed, of a dark segment, bordered by a luminous arch, which is subject to constant changes. Now at one extremity, and now at the other, and again at intermediate points, clouds of light suddenly appear, and stream upward from the arch like tongues of fire. These luminous streamers, glowing with tints of crimson, yellow, and green, move back and forth upon the auroral bow, and, darting far up into the sky, with a tremulous motion, apparently unite, forming a brilliant mass of light, called the crown, or corona.

The aurora then appears in its greatest splendor, the sky resembling a fiery dome supported by undulating pillars of flame, while over all waves and coruscations of prismatic light pass in quick succession.

In the ordinary auroras seen in the temperate climes, the corona is not found, and the brightest tints are wanting: yet at times within these limits splendid exhibitions occur. In the polar regions they are beheld in the greatest magnificence; for there the arches, their vivid streamers flushed with the richest prismatic hues, are seen passing successively over the heavens and forming brilliant curtains of light. No less than nine such arches were seen at once, by M. Lottin, at Bossekop, in West Finmark, hanging behind each other, their luminous folds extending across the sky.

AURORA BOREALIS.

One of the most extensive and splendid auroral exhibitions on record is that which occurred on the 2d of September, 1859, and continued till September 4th. It extended over every meridian of the Northern Hemisphere, and was seen from about the 60th degree of north latitude to the 50th degree of south latitude. Throughout the whole of this vast region the aurora was displayed in all its varied phases of magnificence and beauty. Luminous arches spanned the heavens, resting upon crimson masses of light; streamers brilliant with hues of crimson, scarlet, orange, yellow, green, and purple, flashed upward through the sky; while high in the heavens glowed the auroral crowns.

At Lunenburg, Massachusetts, says Professor Rogers, the display attained its highest magnificence. The dome of the heavens was hung around with white, golden, and rose-tinted streamers, converging from all quarters towards the magnetic pole. Over the glowing stripes of this marvellous pavilion there came broad flashes of the richest crimson light, until it suffused all the upper part of the sky and nearly the whole southern portion of the heavens.

12. **Origin.**—The aurora is supposed by many eminent philosophers to be electric in its origin; while others regard electricity as a result of the aurora, and not the cause. The first view is greatly strengthened by the decided electric phenomena that marked the great aurora of 1859. All the varied and well-known effects of electricity were then exhibited on a grand scale. Such powerful electric currents were developed by the aurora on the telegraphic lines that in many places all communications were interrupted, streams of fire flashed forth from the wires, combustibles were ignited, and severe shocks received by the operators. In several instances the ordinary battery was dispensed with, and the auroral current was employed for working the telegraph.

13. **Uses of Electricity.**—For ages the electricity of the globe, displayed in the aurora and the thunder-storm, was only an object of admiration or terror, and mankind were in the most profound ignorance of its laws and phenomena. But within a century the researches of philosophers have thrown a flood of light upon the subject, and we are beginning to see in this mysterious influence a useful and mighty agent, which, like the nervous fluid in the body, works through the complicated organism of the globe, moulding, controlling, and energizing all things, and contributing its powerful aid to the progress of mankind.

Currents of electricity, circulating around the earth, render it a magnet, and cause the compass-needle of the mariner to point to the northern magnetic pole. Upon this little instrument, thus directed, depends the commerce of the world. Man has subdued this mighty power, and it now works at his bidding. Metals, in every form that art can devise, are plated with gold and silver by the action of electricity. It facilitates, also, the operation of the press: the pages before us are printed from a copy of the original type, taken by the moulding power of electricity. But, more than all, across continents and through the depths of the ocean we now speak to each other by the telegraphic wire.

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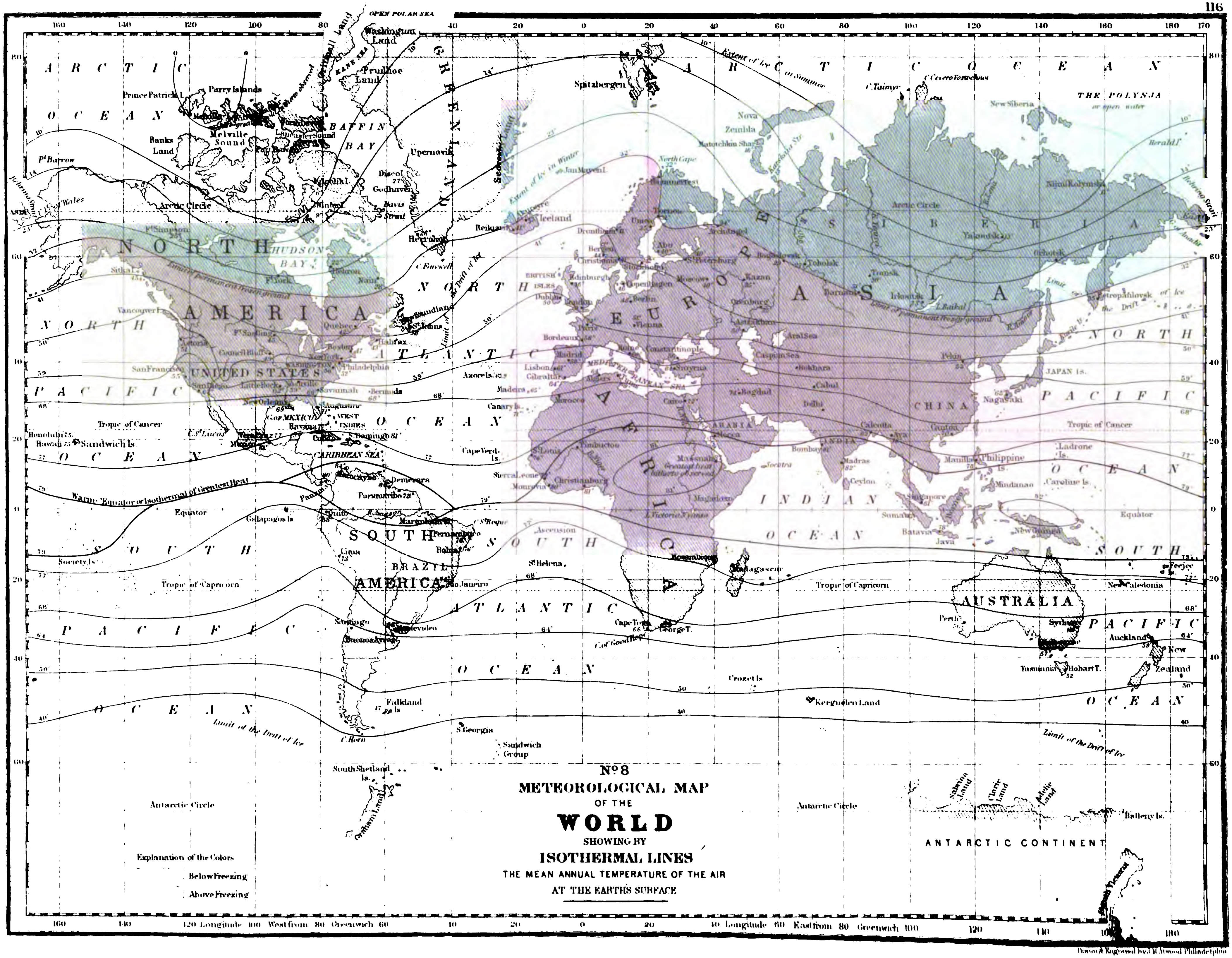
10. What was Franklin's discovery in respect to lightning? What did he invent? Describe the lightning-rod, and show why it affords protection from lightning. To what extent will a rod protect? 11. What is the Aurora Borealis, and the Aurora Australis? Describe this phenomenon. What is said of its beauty in the temperate climes? Where does it appear in the greatest magnificence? Describe the aurora of the 2d of September, 1859. 12. State what is known respecting the origin of the Aurora Borealis. What effects does it produce? 13. What is said respecting the uses of electricity?



Nº 8
METEOROLOGICAL MAP
OF THE
WORLD
SHOWING BY
ISOTHERMAL LINES
THE MEAN ANNUAL TEMPERATURE OF THE AIR
AT THE EARTH'S SURFACE

Explanation of the Colors
Below Freezing
Above Freezing

Drawn & Engraved by J. H. Atwood Philadelphia

REVIEW AND MAP QUESTIONS ON METEOROLOGY.

CHAPTER I.

What is Meteorology? Mention the subjects it comprises.

What is the atmosphere? What is its constitution?

State what is said of its pressure. Of its density. Of its temperature. Of its height.

CHAPTER II.

How is the atmosphere warmed? How is this warmth measured?

What is remarked in regard to the changes in its temperature?

What is said of the mean temperatures?

What is wind? How does it, for the most part, originate?

Explain how a difference in the temperature of contiguous regions can produce winds.

How are winds classified in regard to their duration?

Describe the trade-winds, their origin, limits, and deflections.

Show on the map (page 92) the extent of the trade-winds, and over what countries and oceans they prevail.

Describe the zones of calms, their cause and limits.

Point out on the map their respective positions.

Describe the upper and lower westerly winds, and give illustrations.

Show on the map the regions where westerly winds prevail.

Where do the southwest and northwest winds predominate?

Describe the monsoons, their prevalence and origin.

Point out on the map the ranges of the monsoons in the Pacific and Indian Oceans, and their seasons.

What monsoons prevail on the east and west coasts of Central and South America.

Describe, from the map, the winds of the western coast of Africa.

What are land and sea breezes? Describe and explain them.

What are Etesian winds? Explain them.

What are the Northers? Point out their locality on the map.

Give an account of variable winds.

What are Professor Coffin's views in respect to the systems of winds?

What is said of the nature of winds?

Point out on the map the districts of hot and dry winds.

Describe the cold winds. What are Cyclones? Describe them.

Explain from the small map on page 92 the rotations and tracks of hurricanes in the Northern and Southern Hemispheres.

Point out on the map (page 92) the hurricane districts.

Where is the region of typhoons, and when do they prevail?

Describe and explain tornados and water-spouts.

What advantages have resulted from the study of winds, tides, and ocean-currents?

Describe from the text, and trace out on the map, the routes from the United States to Europe, and the return-tracks.

Explain in the same way the routes from the United States and Europe to Australia, India, and China, and the return-tracks; also the routes from the United States and Europe to California and the Northwest coast.

Explain from the text and map the routes from California to China and back.

Point out on the map the routes from the United States and Europe to the Sandwich and Society Islands.

From San Francisco to Australia, and from Australia to Callao.

Explain the use of storm cards.

What advantages arise from winds?

CHAPTER III.

What is said respecting the moisture of the atmosphere?

How is rain caused?

What is said of the distribution of rain in latitudes?

Show, from the Rain Map (page 98), that this is the general law.

Show the same from the Ocean-Currents Map (page 87).

How do maritime and inland regions in the same latitude compare as respects their annual rain-fall?

Prove this rule from the map (page 98) in the case of the United States.

Show from the map that more rain falls yearly upon the western coasts of the two continents than on the eastern.

What is the effect of height on the rain-fall?

Prove the rule from the map.

Where is the greatest annual rain-fall?

Name the places where the annual rain-fall exceeds 225 inches. Name some of the places where it ranges between 100 and 50 inches. Where it falls below 50.

How do rains occur within the tropics?

Why is the year here divided into the dry and rainy season?

Point out on the map the regions where this division prevails.

Show from the Rain Map of India (page 98) the peculiar distribution of rain which here occurs.

Trace on the map the rainless districts of the globe.

Show on the map the regions where the rains are almost constant.

Point out on the map the limits of the summer, autumn, and winter rains. Can rain occur without clouds? Why?

What is the annual rain-fall of the globe?

What are fogs and mists? How do they originate?

What is dry fog, or haze?

What are clouds? How are they caused?

What is said of their height and thickness? How are they classified?

What is dew? How is its deposition influenced?

What is said of its distribution? What is hoarfrost?

How is it caused? What is snow? Describe the snow-flake.

What is said of the distribution of snow? What is the snow-line?

Trace on the map the limit of snow in latitude in the Northern Hemisphere, and show through what countries it passes.

Trace in like manner the snow-curve of the Southern Hemisphere.

What is hail? Describe the hailstone. Explain the origin of hail.

Describe the Alpine snow-fields and avalanches.

Describe glaciers, their extent, formation, structure, color, and motion. What are moraines and icebergs?

What is said respecting the distribution of atmospheric moisture?

CHAPTER IV.

What is meant by the climate of a country?

By what causes are the temperature and moisture of any region greatly modified?

Explain the effect of latitude. Of height above the sea-level.

Of the position and direction of mountain-chains, and of table-lands.

What is said respecting regions near to or remote from the sea-coast?

How is climate affected by prevailing winds?

Explain the effect of ocean-currents.

Is climate influenced by the nature of the soil, and by cultivation?

What is miasma? Where does it occur, and what are its effects?

What are isothermal lines, and what is said respecting them?

What is meant by the warm equator?

Show from the map (page 116) through what countries it passes.

Why is it found sweeping so much to the north?

Show from the map the position of the locality which has the greatest known annual temperature.

Why do the isothermal lines extend farther to the north on the western than on the eastern coasts of the continent?

Point out on the map the regions through which the isothermal of 77° Fah. runs in the Northern Hemisphere, and give the mean temperatures of the cities, islands, and other places which are near it.

Follow in the same way the isothermals 68°, 59°, 50°, 41°, 32°, 23°, 14°, 10°, and 0° Fah.

Trace in like manner the isothermals of 77°, 68°, 64°, 50°, and 40° Fah. in the Southern Hemisphere.

Show on the map the limit of the drift ice in the Southern Hemisphere. Trace the limit of the ice in winter and summer in the Arctic Ocean.

State what was observed by Dr. Kane, and the inference he drew from this fact.

What are the zones of climate? How are they characterized?

Give an account of the hot zone, and name the countries included within it.

Describe in like manner the warm, temperate, cold, and frigid zones.

What countries possess on the whole a temperate climate?

What a tropical climate?

CHAPTER V.

Mention the optical phenomena of the atmosphere.

Give a description and explanation of each, and cite the illustrations.

What are the luminous phenomena?

Give an account of meteorites and shooting stars, and the theories respecting them. What is said of the ignis-fatuus?

CHAPTER VI.

What is said of electricity?

Give an account of atmospheric electricity, and describe its various phenomena.

State what is said of the Aurora Borealis.

What are the uses of electricity?

TROPICAL FOREST.

PART SIXTH.

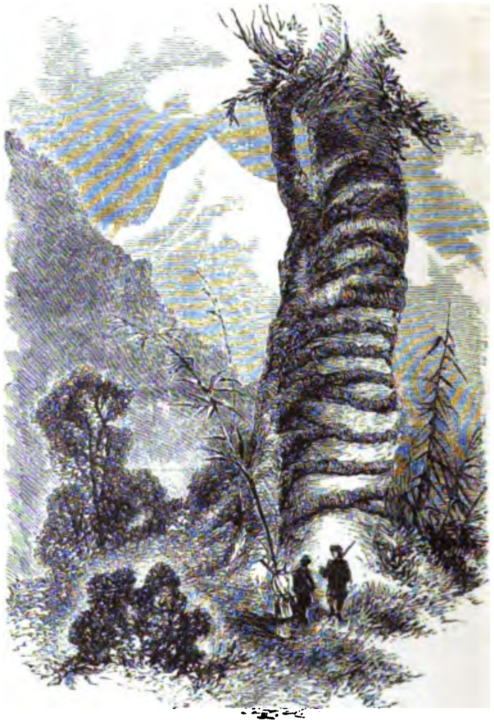
THE LIFE OF THE GLOBE, AND ITS DISTRIBUTION.

Thus far we have treated chiefly of inorganic matter, existing in the forms of Land, Water, and Air, and moved only from *without* by chemical and mechanical forces. We are now, so far as relates to its distribution over the globe, to consider organized matter, endued with life and influenced from *within*. Lowest in the scale is the *Plant*, moored to the soil, though gifted with vitality; next the *Animal*, which in addition to life possesses instinct, will, and the power of voluntary motion; and lastly, at an immeasurable distance, comes *Man*, endowed with intellect and an immortal soul. This department of Physical Geography is, therefore, naturally classed under three divisions,—namely, *Geographical Botany*, *Geographical Zoology*,[1] and *Ethnology*.[2]

CHAPTER I.

GEOGRAPHICAL BOTANY.

1. **Vegetation** extends all over the globe, existing under the most diversified conditions of heat, light, and moisture. In the equatorial and tropical regions, wherever moisture abounds it flourishes in unrivalled magnificence and splendor. The stately trees of the forest glow with blossoms of scarlet, purple, blue, pink, and golden hues, beautifully contrasting with the dark green of the glossy leaves. Bright orchids bloom amid the branches, and huge serpent-like creepers, wreathed and clustered with brilliant flowers, entwine the trunks and trail from tree to tree, till the forest overflows with its wealth of beauty. On the rivers floats the magnificent lily the *Victoria Regia*, whose leaves are six feet long, and its flowers of blended white and crimson twenty-three inches in diameter; while the banks of the streams are fringed with flowering trees, like the Astrapææ, which stretch over the water their broad-leaved branches, vivid with thousands of globular rose-tinted blossoms.



HIMALAYA CLIMBING PLANT.

Passing from the equatorial to the temperate climes, the forms of vegetation are entirely changed, and its beauty is more subdued. The forest no longer consists of flowering evergreens, but in their place rise the oak, ash, maple, birch, chestnut, elm, beech, and walnut, which shed their foliage at the approach of winter. Here the apple, pear, plum, cherry, and peach abound, and the vine yields its rich fruitage. The reed-like grasses of the tropics give place to a soft and tender herbage, the bright green meadows are enamelled with lovely flowers, and abundant harvests of grain wave over the well-tilled soil.

Advancing from the temperate to the polar climes, tall forests of fir, pine, and birch are seen clothing the mountain-sides, as in Central Russia, Norway, British America, and the Northern United States; but many kinds of trees and grains have disappeared. In the polar zone there are no forests; but low flowering annuals, such as the saxifrages, gentians, spireæ, and chickweed, spring up and blossom with wonderful rapidity during the brief arctic summer. In the coldest latitudes, lichens and mosses spread over the rock and frozen soil, while hardy microscopic plants, of crimson hues, grow amid the snows with a surprising vigor.

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[1] From the Greek words *zoon*, an "animal," and *logos*, a "discourse."
[2] From the Greek words *ethnos*, a "nation," and *logos*, a "discourse."

What is the subject of Part Sixth? 1. What is the nature of the forms of matter which have thus far been discussed? What are we now to consider? Under what conditions does it exist? How is this part of Physical Geography divided? Of what does Chapter I. treat? 2. What is said of the extent of vegetation? Where is it most luxuriant and splendid? Describe the vegetation of the tropical, temperate, and polar climes.

2. **Species.**—These diversified conditions of vegetable life are marked by different species, and each clime has its own peculiar type of vegetation, termed its *flora* (from the Latin word *flora*, a "flower"). To describe the various classes of vegetable forms, and their distribution over the earth, is the province of Geographical Botany.

With the progress of discovery and research, the number of the known species both of plants and animals has greatly increased. The Greeks were acquainted with only 500 species of plants; but at the present day botanists enumerate 120,000, and the list is constantly increasing with the exploration of new regions of the earth. It is estimated that the entire flora of the globe probably comprises from 150,000 to 200,000 species. The species are more numerous in warm than in cold climates. Thus, Jamaica possesses four thousand species of flowering plants, and Spitzbergen only forty-five. The same fact is observed as we ascend from the base of lofty mountains to their snow-clad heights.

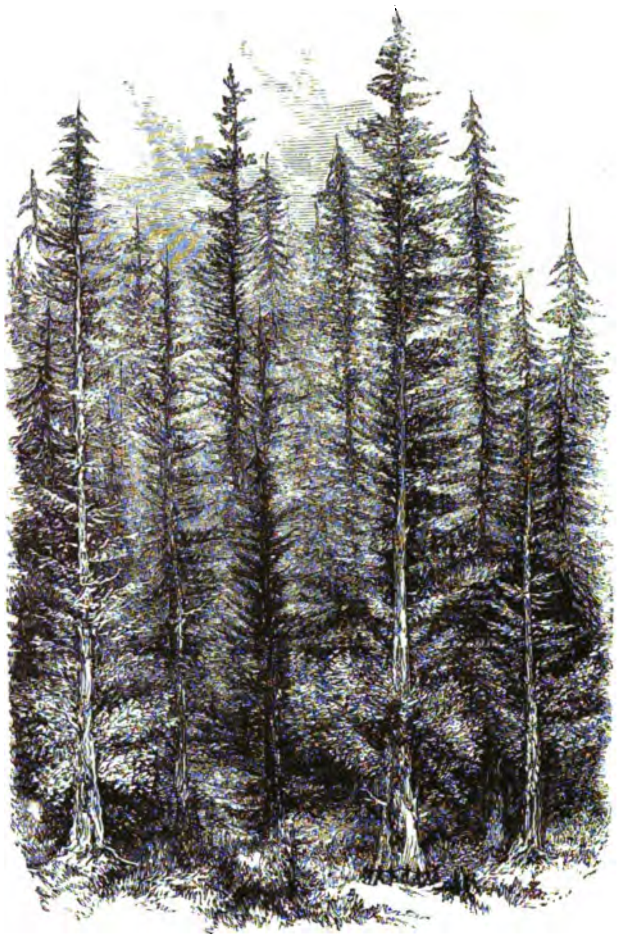
3. **Divisions and Classes.**—The forms of vegetable life are comprised by botanists under two great divisions,—Phanerogamia, or flowering plants, and Cryptogamia, or flowerless plants. The former is also divided into two large classes, differing essentially in structure,—namely, the Exogens[1] and Endogens.[2]

An exogenous plant is one whose stem grows by additions *from without*, as in the case of the oak, where successive rings of wood form beneath the bark year by year. The exogens constitute the most numerous, perfect, and beautiful class, comprising the forest trees and nearly all the flowering shrubs and herbs.

The grandest and most enduring forms of vegetable life are found in the exogens. Thus, the Adansonia, or *baobab* of Senegal, though it rarely attains a height greater than fifty or sixty feet, is sometimes so large that, according to Malte Brun, twenty men joining hands cannot encircle it. Mr. Adanson estimated the age of a baobab in Senegal to be over five thousand years. In Oaxaca, in Mexico, is a magnificent cypress over ninety-three feet in circumference, which shows not the slightest token of decay. On the mountains of Lebanon a few of its famous cedars still remain,—the largest measuring nearly fourteen feet in circumference. From the observations made upon a few of its outer rings, it has been estimated to be three thousand five hundred years old.

To this class belongs the curious banian-tree of India, whose pendent shoots, thrown out from its horizontal branches, take root in the earth and form new trunks, until at length a grove arises from the parent tree. Forbes relates that on the banks of the Nerbudda is a celebrated banian, which, though much of it has been swept away by high floods, still covers an area of more than 2000 feet in circumference, the principal trunks amounting to 350 and the smaller to 3000. This tree has been known to shelter an army of more than seven thousand men. The Parliament Oak—so called from the tradition that Edward I. held a Parliament beneath its branches—is supposed to be fifteen hundred years old.

But exceeding all other vegetable forms in grandeur are the giant pines of California. A grove of these trees, eighty-five in number, is scattered over an area of about fifty acres, near the head of the Stanislaus River.



CALIFORNIA PINE.

One of these trees was cut down about twelve years ago, and measured 322 feet in length, and 95 feet in circumference. Its age, according to Dr. Torrey, was 1120 years,—this number of concentric layers being counted in a cross-section of the tree. Another, not far distant, towers to the height of 350 feet, and measures 97 feet in circumference. A third, which has fallen, is estimated to have been 400 feet high, and has a circumference of 110 feet. It is decayed within for 250 feet of its length; and through the hollow of the trunk, ten or twelve feet high, a man on horseback can ride the whole distance.

The *Endogens*, which increase their stem by additions from *within*, embrace such forms of vegetation as the palm, plantain, sugar-cane, the grasses, and all the grain-yielding plants, and are more distinguished for their usefulness than their beauty, except in a few cases. Chief among the endogens are the palms, called by Linnæus the "princes of the vegetable kingdom." They are remarkable for the size, height, and straightness of their stems, shooting up, in favored situations, to the height of two hundred feet, tapering gracefully from the base to the summit, and surmounted with a magnificent crown of gigantic leaves.

An extraordinary tree of this class is the *traveller's tree*, which is found in Madagascar. According to Mr. Ellis, it springs from the ground with a thick, juicy stem, like that of the plantain, and rises to the height of from ten to thirty feet. At its top it sends out from its stem, on opposite sides, from twenty to twenty-four leaves of great size, the stalk being from six to eight feet long, and the leaf itself from four to six feet broad; its foliage presenting the appearance of an immense open fan. These trees contain, even during the driest season, a large quantity of pure water, and supply to the traveller the place of wells in the desert.

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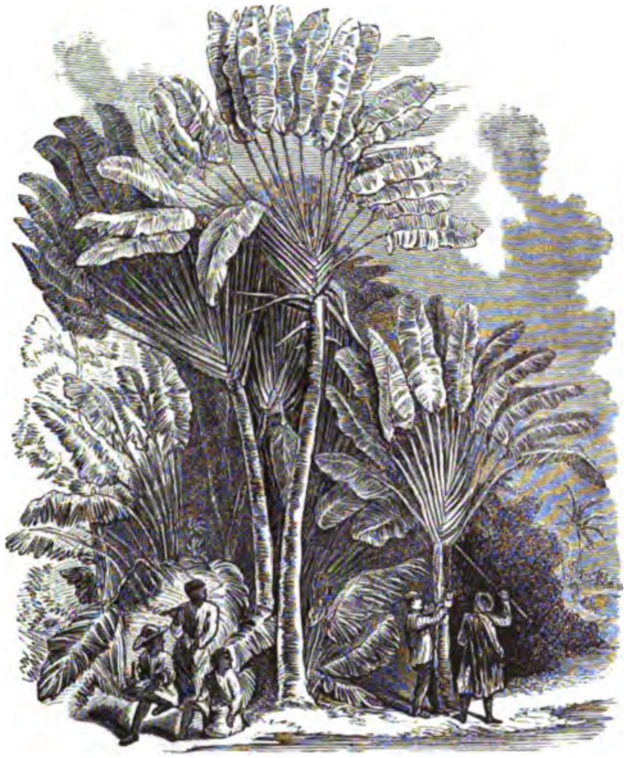
[1] From the Greek words *exo*, "from the outside," and *gennao*, to "produce."
[2] From the Greek words *endon*, "within," and *gennao*, to "produce."

What is produced by these different conditions of vegetable life? 2. What is meant by the term *flora?* What is the province of Geographical Botany? What is the number of the known species of plants? How many are supposed to exist? Where are the species most numerous? 3. Under what two great divisions are all vegetable forms comprised? Into what classes is the first division separated? Explain the structure of an exogen. What is said respecting this class of plants? Give the illustrations. Describe the structure of an endogen. What forms of vegetation does it comprise, and what is said of them?



TRAVELLER'S TREE, MADAGASCAR.

"During my journey this morning," says Mr. Ellis, "we stopped near a clump of these trees. One of my bearers struck a spear four or five inches deep into the thick, firm end of the stalk of the leaf, and on drawing it back a stream of pure water gushed out, a quart of which we caught in a pitcher and drank. It was cool, clear, and perfectly sweet." There is a natural cavity at the base of the stalk, in which the water is collected from the broad leaf.

The division of the Cryptogamia is widely diffused, and embraces the ferns, mosses, lichens, sea-weeds, and fungi or mushrooms. The ferns are extensively spread over the globe, and are splendidly developed in the tropical regions, where the slender and lowly stem is changed into a woody trunk, rising to the height of from forty to eighty feet, and crowned at the summit by a verdant dome of graceful leaves.

These three great divisions of the vegetable world, branching out into their numerous subordinate forms, under the diversified conditions of climate, mantle the earth from pole to pole, and clothe the loftiest mountains from the base towards the summit; while the ocean is filled with algæ, or sea-weeds,—a class of cryptogamic plants.

Different tribes of plants require different conditions of light, heat, and moisture for their development; and each clime is thus characterized by its peculiar type of vegetation. Physiologists have, therefore, divided the flora of the globe into different zones, each limited by isothermal lines and distinguished by its prevailing forms of vegetable life.

4. **Zones of Vegetation in regard to Latitude.**—The Northern and Southern Hemispheres may be both divided into seven *zones*, or *botanical regions*, each characterized by the peculiar forms of vegetation which there flourish best, though these may exist beyond the confines of their proper zone. On each side of the equator is the zone of *palms* and *spices*, bounded by the isothermals of 78° Fah. Between these limits on the north, and the isothermals of 68° Fah., is the zone of the *sugar-cane* and *coffee-tree*. The next zone is bounded by the isothermal of 59° Fah., which is the polar limit of the *orange*, *olive*, and *fig*. The zone of the *vine* comes next, limited by the isothermal of 50°. The region between the isothermals of 50° and 41° is the zone of the *bread-grains*. To this succeeds the zone of *firs*, *pines*, and *birch*, between the isothermals of 41° and 32° Fah. The seventh and last zone stretches beyond the latter towards the north pole, and is the region of *shrubs*, *mosses*, *lichens*, and *fungi*. The zones of the Southern Hemisphere lie between the same isothermals as in the Northern Hemisphere.

5. **Zones of Vegetation in respect to Altitude.**—The snow-capped mountains of the tropical regions near the equator, sinking in temperature from base to summit, present the same variety of climates that exists between the equator and the poles, and are marked by similar flora. According to Meyen, the belts of vegetation in the equatorial climes may be distinguished as follows:—

In the *first* zone, which extends to the height of 1900 feet above the sea-level, palms, bananas, the bread-fruits, the sugar-canes, and bamboos flourish, and other plants indigenous to the hot climes.

The *second* zone is comprised between the heights of 1900 feet and 3800 feet, and abounds with the tree ferns, figs, pepper, and cinnamon, and corresponds to Senegambia and Madagascar in its vegetable forms.

The *third* zone lies between the altitudes of 3800 and 5700 feet: it is the region of the magnolia, laurel, myrtle, and cactus, and its vegetation is the counterpart of the flora of the Southern States and of Mexico.

The *fourth* zone, which reaches the limit of 7500 feet, is the region of the evergreens; and here flourish the orange, pomegranate, olive, and vine.

TREE FERN.

The *fifth* zone attains the elevation of 9500 feet, and produces the vegetation that abounds in England and the northern United States. Here the oak, ash, maple, beech, and chestnut, spread out in forests; the apple, cherry, peach, and pear flourish; and wheat, with the various bread-grains, yields abundant harvests.

The *sixth* zone is covered with fir, pine, larch, and spruce. It is bounded by the height of 11,400 feet, and the type of its flora is that of Siberia or Norway.

The *seventh* zone, which is limited by the altitude of 13,300 feet,

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Describe the palm and the traveller's tree. What is said respecting the Cryptogamia? Will all plants flourish under the same conditions of light, heat, and moisture? What, therefore, do we find in different climes? How have physiologists divided the flora of the globe? What is said of these zones? 4. Describe the different zones of vegetation in regard to latitude. 5. Describe the different zones of vegetation in regard to altitude.

produces larches, alder, and willow. Grasses are here found, and lichens and mosses flourish.

The *eighth* and last zone extends to the height of 15,200 feet. It is the region of alpine vegetation: no shrubs are seen, saxifrage occurs, and lichens abound.

6. **Marine Vegetation.**—The ocean, like the land, has its peculiar types of vegetation, variously distributed both in regard to latitude and depth. The Northern Ocean from the pole to the 40th parallel, the Atlantic off the eastern coasts of South America, and the China and Japan Seas, are vast marine fields, each having its own forms of vegetation. The Gulf weed forms the Sargasso Sea, situated within the circuit of the Gulf Stream. A species of sea-weed is sometimes found on the shores of the Falkland Islands, twisted up by the surf into enormous cables, hundreds of feet in length, and thicker than a man's body.

The types of marine plants vary with the depth. The fuci extend ninety feet below the surface of the sea, and the common algæ, or sea-weed, three hundred feet; while in the bed of the ocean microscopic vegetable forms alone exist.

7. **Diffusion of Plants.**—Every species of plant requires certain physical conditions for its growth and perfection; and these may be either general or special. If general, then it will be widely diffused; but if special, its distribution will be limited. To the former class belongs the thistle, which, transported from Europe to South America, now covers the Pampas for leagues with its dense growth of gigantic stalks; and to the latter, the *Disa grandiflora*, which, according to Herschel, is found only on the summit of the Table Mountain at the Cape of Good Hope. On the sand-rock of Tunbridge Wells there also grows a certain plant which has been discovered in scarcely any other locality. The cinchona, which furnishes the Peruvian bark, is likewise confined to a particular region along the Eastern Andes. Such cases, however, are exceptional.

Some plants are confined to one hemisphere. It is stated by Petermann that more than three hundred varieties of heath grow within a narrow broken belt stretching from high northern latitudes of the Eastern Continent as far as the Cape of Good Hope, while not a solitary species is indigenous to America. Only a single native species of the peony has been found in the Western Continent, which, however, is rich in the tribes of the cactus, a plant unknown to the Eastern Hemisphere.

Every species of plant is regarded as having been once created in a particular locality, and thence disseminated, by various agencies, to an extent accordant with its capacity for diffusion.

The winds, rivers, ocean-currents, birds, and beasts are active agents in the dispersion of plants. Thirteen species of plants indigenous to Africa, in the vicinity of the river Zaire, are found on the shores of Guiana and Brazil, their germs being borne across the ocean by the Equatorial current. The seeds of the cashew-nut and other tropical plants are carried by the Gulf Stream from the West Indies to the coasts of Scotland.

Man especially contributes to their diffusion, stimulated by the desire to add to his comforts and luxuries. Plants that are susceptible of wide dissemination become very much improved in their properties by cultivation under varied conditions of soil and climate. This is strikingly seen in the potato and crab. The former, which in its native state is a small tuber growing wild in the tropical region of South America, when cultivated in temperate climes increases in size and improves in its nutritive properties, and has now become one of the most important articles of food. The latter is the poorest stock of the apple, but under cultivation has grown larger, lost its bitter properties, and gained that rich variety of flavor which belongs to this well-known and much-prized fruit.

The Romans introduced most of the finer European fruit-trees,—some from Africa, as the pomegranate, but the greater part from Asia, as the orange, fig, cherry, peach, apricot, apple, and pear. They obtained the strawberry from Mount Ida. The damson plum and damask rose originated at Damascus.

To treat of all the species of the vegetable kingdom, with their diversified forms and properties, is the province of the botanist, and comes not within the scope of this work. We shall confine ourselves to the description of those important plants which contribute to the support, comfort, relief, enjoyment, and tastes of man.

8. **Plants yielding Food.—Equatorial and Tropical Climes.**—The principal food-producing plants of these climes are *Rice, Dhurra, Bananas, Plantain*, the *Yam*, the *Date-Palm*, the *Cocoa-Palm*, the *Bread-Fruit tree*, the *Fig*, the *Sago-Palm*, and the *Mandioc*.

Rice belongs to the tropical regions, but is widely cultivated beyond them. It is the chief food in Eastern and Southern Asia, and a common article of diet throughout tropical Africa, Persia, Arabia, Asia Minor, the Barbary States, and a portion of Europe. It is cultivated also in the West Indies, Brazil, and the Southern United States. Rice is of doubtful origin. It was cultivated very early in Persia, and thence extended to Greece, Italy, and Spain. In 1522, Columbus brought it to the New World. According to Henfrey, rice probably supports a greater number of the human race than any other plant.

Dhurra is a small kind of grain, extensively cultivated in India, Egypt, and the interior of Africa. It yields a beautiful white flour, as nutritious as that of wheat.

The *Banana* is regarded as originating in the southern part of Asia, whence it was carried to the Indian Archipelago, Africa, and America. It is a beautiful plant, having leaves six feet long and one foot broad, from the bases of which hang clusters of fruit of the shape of a cucumber, consisting of a sweet and soft pulp, which is used as food in a variety of ways. It is exceedingly productive; for, according to Humboldt, while a thousand square feet of soil will produce only 38 pounds of wheat, or 462 pounds of potatoes, it will yield 4000 pounds of bananas, and within a shorter time.

The *Plantain* is a species of banana, growing to the height of fifteen to twenty feet, and producing a similar nutritious fruit.

The *Yam* is a slender vine, having large tubers, like the potato, which form a palatable and wholesome food. It is cultivated in the East and West Indies, Africa, and the isles of the Pacific. The roots are sometimes three feet long and weigh thirty pounds.

The *Date-Palm* is a native of Northern Africa, growing wild upon the northern slopes of the Atlas Mountains, and yields the date, an invaluable article of food to the dwellers in the desert. So abundant are these trees in this region that it is called Beled-el-Jerid, or the "land of dates," and the date itself is termed the "bread of the desert." Wherever even a spring of water appears amid the arid wastes

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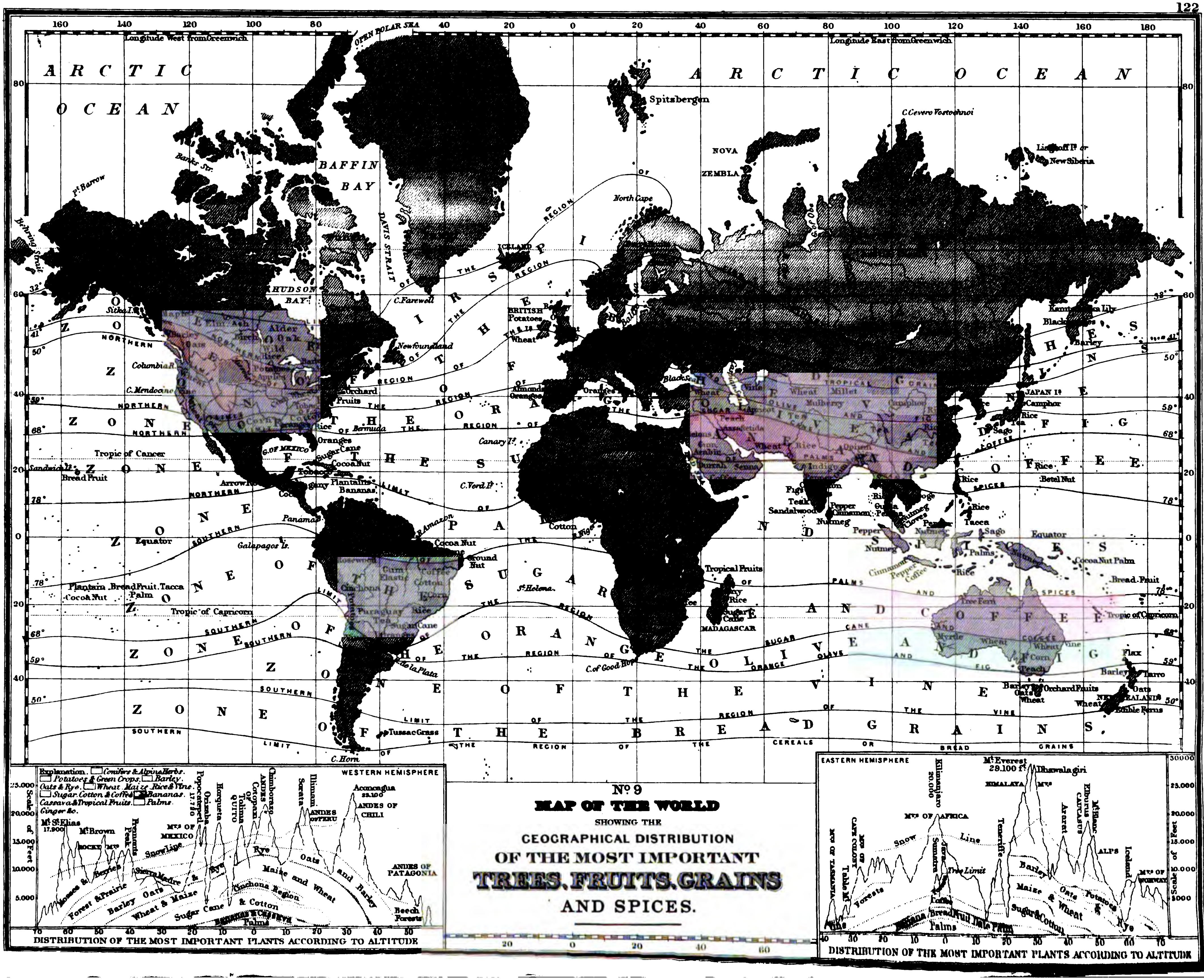
6. What is said of the vegetation of the ocean? 7. What is said of the diffusion of plants? When will a plant be widely diffused? When will its extension be limited? Give instances. Are some plants confined to one hemisphere? Give the cases. Mention the several agencies by which plants are disseminated. What effects are produced upon plants by cultivation and by different soils and climates? Give the illustration. What is said of the origin of some of our finest fruit-trees? Whence came the damask rose? What plants are now to be described? 8. Name the principal food-yielding plants of the equatorial and tropical climes. State what is said respecting rice, dhurra, bananas, and the yam. Describe the date-palm.



Nº 9
MAP OF THE WORLD
SHOWING THE
GEOGRAPHICAL DISTRIBUTION OF THE MOST IMPORTANT TREES, FRUITS, GRAINS AND SPICES.

of Africa between the 19th and 35th degrees of north latitude, there is beheld this graceful palm, affording at once a welcome shelter and a nourishing fruit. When all other crops fail from drought, the date-palm still flourishes. In Egypt and Arabia it constitutes a large portion of the food of the inhabitants, and among the oases of Fezzan nineteen-twentieths of the population live upon it for nine months of the year. A single date-palm produces, on an average, from 150 to 200 pounds of fruit, and continues to bear for more than two hundred years. The date-palm also grows in certain parts of Southern Europe, and in Asia is found in Syria and the south of Persia and on the banks of the Indus.

COCOA-PALM.

The *Cocoa-Palm* is valuable, not only for the food it yields, but for its timber, fibre, and foliage. It is indigenous to Southern Asia, but has been discovered throughout the tropical countries of the Eastern Continent, and abounds in the Indian Archipelago. It grows also in South America, and thrives luxuriantly in the isles of the Pacific. Slender and graceful, it rises to the height of seventy or eighty feet, crowned with a tuft of from twenty to thirty leaves six or seven yards in length, and from between them, at their bases, spring branches of tendrils, on which grows the well-known cocoanut. "These noble fruits," says Bennet, "encircle the top of the stem, like a beaded belt, beneath the pendent crest of their plume-like leaves. The kernel of the nut yields nutritious food and useful oil, its milk a cool and refreshing beverage, and the fibres of its enclosing husk are twisted into ropes. The trunk is used for timber, the leaves are employed for thatching houses and woven into mats and baskets, and the shells are formed into drinking-cups. The cocoa-palm when about six years old begins to bear fruit, which is a year in coming to perfection. A single tree sometimes produces a hundred nuts at a time."

The *Bread-Fruit tree* is a native of the Indian Archipelago and of the South Sea Islands, but flourishes best in the Friendly and Marquesas Islands. It is likewise found in Southern Asia, and has been diffused through the West Indies and Brazil.

It is a beautiful tree, like the ash in form, and grows to the height of forty feet, being covered with bright green leaves more than a foot in length. The remarkable fruit which it bears is egg-shaped, of a pale green color, and measures about twenty-two inches around in the shortest direction and twenty-five in the longest. The pulp, when baked, is soft and mealy, resembling in color and taste fine sponge biscuit. It is a wholesome and delicate substitute for bread, and is very nutritious. The produce of this tree is enormous, as it yields four crops a year; and it is said to be even more productive than the sago and banana. "Whoever in the South Sea Isles," says Captain Cook, "has planted ten bread-fruit trees, has fulfilled his duty to his own and succeeding generations as completely as an inhabitant of the cooler temperate climes who has toiled through his life to provide for his household and amass a fortune for his children." The bread-fruit tree has never been found wild.

The *Fig* is an extensive article of food in many countries. Barley bread and dried figs are now the ordinary food of the lower classes in Greece and the adjacent islands. About 1000 tons of figs are annually imported into Great Britain. In a perfectly dry state the fig is about as nutritious as rice.

The *Sago-Palm*, which produces a kind of meal, forms large forests in the Molucca Islands. The farinaceous matter is contained in the pith of the tree, and is extracted by rubbing the pith to powder and then washing it with water upon a sieve, when the sago settles upon the bottom of the vessel receiving the water. Each tree of seven years' growth contains seven hundred pounds of sago; and it has been estimated that a single acre of land planted with sago-trees, one-seventh to be cut down every year, will maintain fourteen men. Sago is the chief support of the natives of Northwestern New Guinea, and of many regions on the African coast.

The *Mandioc*, producing cassava, is a shrub six or seven feet high, and having fleshy roots from one to two feet long and as thick as a man's arm. It is a native of Brazil, grows luxuriantly on the west coast of Africa, in Congo and Guinea, and its cultivation extends to about thirty degrees on each side of the equator. The roots of the mandioc contain a poisonous juice, together with a great amount of starch, which is the cassava. This is obtained by grinding the roots and washing the pulp as in the preparation of sago. The mandioc is very productive, and its meal nutritious: an acre of this shrub yields as much food as six acres of wheat. Tapioca consists of the finest and purest portions of the cassava.

Fruits.—In addition to the fruits already mentioned as used for food, the orange tribe of plants, consisting of the orange, lemon, citron, and shaddock, together with the pine-apple, mango, mangosteen, and many others, are highly prized, as they afford abundant supplies of grateful and refreshing fruit in the very climes where it is most needed.

9. **Temperate Climes.**—In the temperate climes, grains, for the most part, constitute the great staples of food, and the most valuable food-producing plants are *Wheat, Rye, Barley, Oats, Indian Corn, Buckwheat,* and *Potatoes.*

Wheat, which is the chief of grains and has been cultivated from time immemorial, flourishes luxuriantly in the temperate climes of both hemispheres, and on the mountain-heights of the torrid zone at the altitude of 10,000 feet. It appears to have originated in Tartary and thence to have spread westward. It was introduced into South America by a Spanish lady, one of the earliest colonists. Immense quantities are now produced in Europe and the United States. In 1860, the amount of wheat raised in this country was 171,183,381 bushels. The geographical northern limit of wheat in Europe is about the 64th degree of north latitude, and in North America it is cultivated as high as the 54th degree of north latitude.

Rye was first known to the Persians. It is largely cultivated in Germany, Sweden, Norway, and Russia, and furnishes bread for one-third of the population of Europe. Its northern limit is about the 67th degree of north latitude, and it grows on the Himalayas at the height of 12,000 feet. In the United States the amount of rye produced in 1860 was about 21,000,000 bushels.

Barley and rye very much resemble wheat, both in their composition

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Describe the cocoa-palm and bread-fruit tree. What is said of the fig, sago-palm, and mandioc? What fruits are likewise found within these climes?

9. What are the principal articles of food in the temperate climes? State what is said respecting wheat and rye.

and nutritive qualities. This grain has been cultivated from the earliest antiquity, and probably is indigenous to Tartary. It was introduced into Germany by the Romans, and was there extensively raised for the purpose of making beer; and to this use it is now chiefly applied both in England and America. In the regions where it is grown, only the poorer classes convert it into bread. From its quick ripening, it is cultivated in Europe as high as 70° north latitude. Nearly 16,000,000 bushels of barley were raised in our own country in the year 1860.

The *Oat-plant* is supposed to be a native of the Caucasus: it was but little cultivated in ancient times, and the grain in the time of Charlemagne was considered inferior to rye. It is, however, very nutritious, and, though principally employed as food for horses, it is a staple article of diet for the poor in Scotland and North Germany. Its northern limit in Europe is about the 65th degree of north latitude. According to the census of 1860, 172,554,688 bushels of oats were raised in that year throughout the United States and its Territories.

Indian Corn, or *Maize*, is probably indigenous to the New World. It has been found wild in the woods of Brazil; and ears of maize have been discovered in the tombs of the ancient Peruvians. From the New World it was carried to the Eastern Hemisphere, being first introduced into Europe, whence it rapidly extended over Asia. In our own country it is extensively cultivated, the quantity raised in the year 1860 being over 800,000,000 bushels.

Buckwheat is probably a native of Northwestern China, and thence, extending westward, was at length introduced into Europe, where it was widely disseminated in the sixteenth century. It is now raised in nearly all parts of Northern Europe, but is most abundantly cultivated in Siberia and on the steppes of Central Asia. Buckwheat flour is about as nutritious as that of wheat.

The *Potato*, so valuable for its root, is a native of Chili and Peru, and was introduced into Europe in the sixteenth century, but was not extensively cultivated till the middle of the eighteenth. It is now, however, widely diffused, being cultivated in Europe from Iceland to Greece, and throughout most of Southern and Eastern Asia. It flourishes, also, at the Cape of Good Hope and in Australia. In warm climates it grows only on the mountains,—the best potatoes in Peru being raised at the height of 7000 feet above the sea-level. Though the potato is an inferior food, being only a little superior to rice, it is, nevertheless, very largely consumed, and is the chief diet of the lower classes in Ireland. No less than 110,000,000 bushels of potatoes were produced in this country in 1860.

Fruits.—Among the most valuable fruits of the extra-tropical climes are the *Grape*, *Apple*, *Pear*, *Peach*, *Cherry*, *Quince*, *Plum*, and *Apricot*.

"No plant," says Carpenter, "affords a more refreshing fruit than the vine; but it may be questioned whether the evil dispositions of man have not turned that into a curse which the bountiful Creator certainly intended as a blessing." The common vine grows wild in Tartary and in North America. It probably extended at a very early period, from its Asiatic centre, over all the regions then occupied by man, and, as civilization advanced, was at length disseminated throughout Southern and Central Europe. Vine-culture is rapidly extending in the United States, and especially in California.

The cultivation of the vine extends, as a branch of husbandry, over a region comprised between the 21st and 30th degrees of north latitude and stretching in length from Northern India to California,—the best wine being made at the centre of this zone. Three thousand millions of gallons of wine are annually produced in Europe. The vine possesses great vitality: many vineyards in France and Italy, now in full bearing, are more than three hundred years old. The other fruits mentioned are too well known to require discussion.

10. **Polar Climes.**—In these frigid climes, where the bread-grains either cease to grow or are produced in but scanty measure, animal food is the chief sustenance of the inhabitants. Thus, on the northern confines of the Russian Empire, reindeer's flesh and milk, together with fish, mosses, roots, and the ground bark of fir, constitute the food of the inhabitants; while in America the Esquimaux derive their support from the walrus, seal, and other marine animals.

11. **Plants yielding Sugar.**—The chief sugar-producing plants are the *Sugar-Cane*, *Date-Palm*, *Sugar-Maple*, and *Beet*.

SUGAR-CANE.

The *Sugar-Cane*, which ranks first among plants of this kind, was almost unknown to the Greeks and Romans, sugar being used by them only as a medicine. It appears to be a native of the tropical climes, and to have originated in the East, and has been cultivated in China and the Pacific Isles from time immemorial. Through Arabia it came into the south of Europe and to the Canary Isles, was carried from the latter region to St. Domingo by the Spaniards in 1520, and from this island has since spread throughout tropical America. The total quantity of sugar now annually extracted from the sugar-cane has been estimated by Stolle at 4527 millions of pounds. Sorghum is a variety of the sugar-cane.

The *Date-Palm* affords a juice which yields a brownish sugar that is extensively manufactured in the Philippine, Molucca, and South Sea Isles. The annual product from this source is about 200,000,000 pounds.

The *Sugar-Maple*, which abounds in the Northern States and in the Dominion of Canada, affords a delicious syrup, and excellent sugar, which is extracted by boiling down the sap obtained from the tree at the beginning of spring. In 1860, nearly 40,000,000 pounds of maple sugar were produced in the United States, and probably one-third as much in British America.

The *Beet* is extensively cultivated in France, Belgium, Germany, and Russia, for the sugar it contains. The amount of beet-sugar now annually produced on the continent of Europe exceeds 362,000,000 pounds; and its manufacture is increasing.

12. **Plants producing Beverages by Infusion.**—Beverages are prepared from the products of certain plants by infusion, which are so grateful and refreshing that their use has become almost universal. The most remarkable of these plants are *Tea*, *Coffee*, and *Cacao*.

State what is said respecting barley, oats, Indian corn, buckwheat, and potatoes. What are some of the most valuable fruits of the temperate climes? What is said of the vine and its culture? 10. What articles constitute the food of the inhabitants of the frigid climes? 11. What are the chief sugar-producing plants? State what is said respecting each of them. 12. What are the principal plants that produce beverages by infusion?

The *Tea-plant* is an evergreen shrub about six feet high, and resembling the Camellia Japonica. It is regarded as indigenous to China, where it still grows wild, as it does also in Japan. China is the great tea-producing country for the world. The regions which supply the greater part of the tea exported to Europe and America lie between the parallels of 25° and 30° of north latitude; but the plant flourishes as far as the 33d degree of north latitude. The finest tea grows between the 27th and 31st parallels, on a low range of hills which is an offshoot of the Peling Mountains.

The tea-shrub is raised from seed, and the young plants, when a year old, are set out in rows from three to four feet apart. The picking of the leaves begins in the fourth or fifth year, and is seldom continued beyond the tenth or twelfth, when the shrubs are dug up and the plantation is renewed.

TEA-PLANT.

The use of tea was not general in China till after A.D. 600; but it is now the favorite beverage of all classes. It is there prepared by pouring hot water upon the leaves, and the simple infusion is drunk, without sugar or milk. Mr. Fortune, while visiting the tea-districts of China, only once met with sugar and a teaspoon.

Tea was first brought to Europe by the Dutch, in 1610, and into England about the year 1650. In 1664 it was so scarce that the English East India Company then sent to the king two pounds of tea as a valuable present; and three years afterwards they issued their first order for the importation of this article, by directing their agent at Canton to send to England one hundred pounds of the best tea he could procure. It has been estimated by Travers that more than a million of tons of tea are now produced yearly in China alone; while a large amount is also raised in Japan, Corea, Assam, and Java.

The *Maté*, or *Paraguay Tea*, is prepared from the dried leaves of a small shrub, the Brazilian holly, which grows spontaneously in the forests of South America. It has been employed as a beverage by the natives of the country from time immemorial; and its use is now almost universal,—maté being drunk at every meal and every hour of the day.

Coffee is the berry of a tree having a dark and glossy foliage, and which, when full-grown, attains in some countries a height of eight or ten feet, and in others averages from fifteen to twenty. It is a native of Abyssinia, where it grows wild among the mountains; and the beverage from its seeds has been used in that country from the remotest times.

Coffee was introduced into Arabia from Abyssinia in the fifteenth century, but was not brought to Europe before the year 1517, and in 1652 the first coffee-house at London was opened. In 1714 a coffee-tree was presented to Louis XIV. by the Dutch; and from this the monarch sent plants to Surinam, Cayenne, and Martinique, whence have originated the coffee-plantations of America. About one hundred and forty years ago, the Dutch carried the coffee-plant to Batavia, whence it has extended over Southern India and the adjacent isles. The whole amount of coffee now annually produced throughout the globe has been estimated at 600,000,000 pounds.

COFFEE.

The bean from which *Cacao* is prepared is the seed of a beautiful tree with bright dark-green leaves, which grows usually to the height of about twenty feet. It is indigenous to the West Indies and Central America, growing wild in Mexico, and forming entire forests in Demerara. When the Spaniards conquered Mexico, they found the beverage prepared from the cacao to be in universal use; and it appears to have been drunk by the Mexicans from an unknown period of time. To this preparation the natives give the name of *Chocolate*.

Cacao was introduced into Europe by the Spaniards in 1510, but was not imported to any extent till about the eighteenth century.

13. **Spice-Plants.**—The principal spice-plants are *Pepper*, *Cloves*, *Nutmegs*, and *Cinnamon*.

Of the *Pepper-plant* there are several hundred species, all of which resemble each other, and flourish in the hottest regions of the globe. Black pepper consists of the berries of a climbing perennial plant, and grows in clusters around a long stem. The plant is a native of Malabar, and is cultivated in Southwestern Asia, Java, Borneo, and the adjacent isles. The annual amount of pepper now raised throughout the world is estimated at not less than 50,000,000 pounds.

Capsicum, or Cayenne pepper, which has properties similar to the black pepper, is produced by a plant of an entirely different order (the Solanaceæ), and grows in pods. It is extensively used in the East and West Indies and in South America, and largely supplies the place of black pepper in the New World.

PEPPER-PLANT.

The *Clove-tree* is an evergreen, belonging to the myrtle tribe, and grows to the height of thirty or forty feet. It is a native of the

Describe the tea-plant. When was tea introduced into Europe? How extensively is it used now? State what is said respecting maté, coffee, and cacao.

13. Name the principal spice-plants, and give a description and an account of each of them.

Moluccas and other islands of the Indian Archipelago, whence it has been disseminated throughout the various regions of Asia, and also been carried to the West Indies. The spice consists of the unripe flower-buds of the tree, and has been used in Arabia from the earliest ages. Cloves were known in Europe two thousand years ago; though Europeans were ignorant of the country whence they were derived until about the sixteenth century. Allspice, or Pimento, is also the produce of a species of myrtle.

The *Nutmeg* is the seed of a juicy fruit similar in appearance to the apricot, and is produced by an evergreen tree of the laurel tribe, which grows to the height of about thirty feet. It formerly flourished only in the Banda or Spice Islands, but is now cultivated in Sumatra and the West Indies. Mace is the covering of the nutmeg.

Cinnamon is the inner bark of the young twigs of a species of laurel which grows to the height of from twenty to thirty feet. It flourishes in Malabar and in the isles of the Indian Archipelago, and has been transported to Brazil and the West Indies. The finest cinnamon is obtained from the numerous shoots that spring up from the roots of the trees. Cassia appears to be the produce of another but inferior species of the laurel, which grows in Eastern China and in the Asiatic isles.

14. **Medicinal Plants.**—In every part of the world, plants are found endowed with peculiar properties and virtues tending to the relief and cure of various maladies and diseases; and it is frequently the case that, where a particular form of disease prevails, Providence has caused the specific to abound. Among the most important medicinal plants are *Cinchona*, or *Peruvian Bark*, *Opium*, *Rhubarb*, and *Aloes*.

The *Cinchona-tree*, of which there are nineteen species, forms extensive forests upon the slopes of the South American mountains, which extend from the 19th degree of south latitude to the 11th degree of north latitude, and lie between the altitudes of 8300 feet and 5000 feet. The tree is said to resemble the cherry; and from its bark is extracted the medicine termed quinine, which is almost a specific for the ague, and is exceedingly valuable as a tonic. This order of plants also furnishes ipecacuanha, which is the powdered root of a creeping plant that grows in the damp and dense forests of Brazil.

Opium, which is an important drug and has long been known as a soother of pain, is found in the milky juice of many plants of the poppy tribe. It is obtained by making incisions in the seed-vessel, when the juice exudes, and, after being hardened by exposure to the atmosphere, is scraped off for use. The white poppy, which yields the best opium, is produced largely only in tropical climates, as in that of India, which country furnishes the chief supply of the world. The two principal ingredients of opium are morphine and narcotine. The former is sedative, and relieves from pain; but the latter is a stimulant, and produces a kind of intoxication.

Rhubarb is the root of a plant that grows wild upon a chain of mountains near the frontiers of China; and nearly all the rhubarb of commerce is said to come from this region. The value of the rhubarb annually imported into England exceeds a million of dollars.

Aloes, which is the thickened juice of several species of aloe-plants, has been long known and extensively used in medicine.

15. **Narcotics.**—The substance narcotine is contained by many plants termed Narcotics. The most important of these are *Tobacco*, *Opium*, *Hemp*, *the Betel-nut*, and *Coca*.

The tobacco-plant is considered to be indigenous to tropical America; for in 1492 Columbus found the Indians of Cuba smoking cigars. In 1560 tobacco was brought to France by Nicot, and in 1568 to England by Sir Francis Drake. It has since become most widely disseminated, as it can be cultivated from the equator to the 50th degree of latitude. Its use has become as extensive as its growth, tea alone excelling it in the amount consumed. According to Crawford, the annual product and consumption of tobacco is 4480 millions of pounds, —equal to the weight of wheat consumed yearly by 10,000,000 men.

Opium is very largely consumed as a narcotic; for more than three and a half millions of pounds are annually imported into China from the East Indies, in spite of prohibitory laws.

It is used as a stimulant in three ways,—being smoked, taken in pills, and in the liquid form of laudanum. It produces a wondrous intoxication and exaltation of mind, followed by a corresponding depression; and its habitual indulgence debases the intellect and ruins the body. An opium-eater, if he begins early, seldom lives to the age of thirty years.

Hemp affords various narcotic preparations, which have been extensively used in both hemispheres from the earliest ages. The ancient Scythians excited themselves by inhaling its vapor; and at the present day hemp is prized as a narcotic throughout Asia, Africa, and Brazil.

Hasheesh, which is the most common form in which it is used in the East, is prepared by boiling the leaves of the plant in water with fresh butter, when a syrup is obtained which is used in confectionery. The plant is also smoked and chewed. The effect produced by this narcotic, according to Dr. O'Shaughnessy, is to produce cheerfulness and an increase of appetite when moderately used; but if taken to excess it causes delirium and catalepsy.

The *Betel-nut* is the seed of one of the most beautiful species of the palm, which is extensively cultivated throughout India and the Asiatic Archipelago for the sake of the nut. This is about the size of a cherry, and is used by chewing small portions wrapped up in the leaf of the betel-pepper, with a little quicklime. Its usual effect is to produce a mild intoxication, but giddiness when used to excess. It ranks next to tobacco in importance, 500,000,000 pounds being annually consumed in the East.

Coca has been termed the "narcotic of the Andes," inasmuch as its use is chiefly confined to the Indians of Peru and Bolivia. It consists of the dried leaf of a shrub which grows in those regions, and is used by chewing it with a little quicklime. It was believed by the ancient Peruvians to have the power of relieving hunger and thirst and of sustaining physical strength. In the opinion of Dr. Tschudi, the moderate use of coca is conducive to health, but when taken in excess it produces excitement, which at length destroys all mental vigor.

16. **Plants which furnish Clothing.**—The chief of these are *Cotton*, *Flax*, and *Hemp*.

The *Cotton-plant* belongs to the tribe of mallows, and grows spontaneously within the torrid zone throughout Asia, Africa, and America. It is, however, cultivated to an immense extent beyond this region, and, under the varying conditions of soil and climate, assumes the form of a tree, of a shrub, and of an herb. The cotton consists of a mass of delicate, soft, cream-colored fibres, which fill the boll and surround the seeds of the plant.

It has been manufactured in India from the remotest antiquity; and from the New World the Spanish conquerors of Mexico brought mantles and robes of cotton which probably surpassed in beauty

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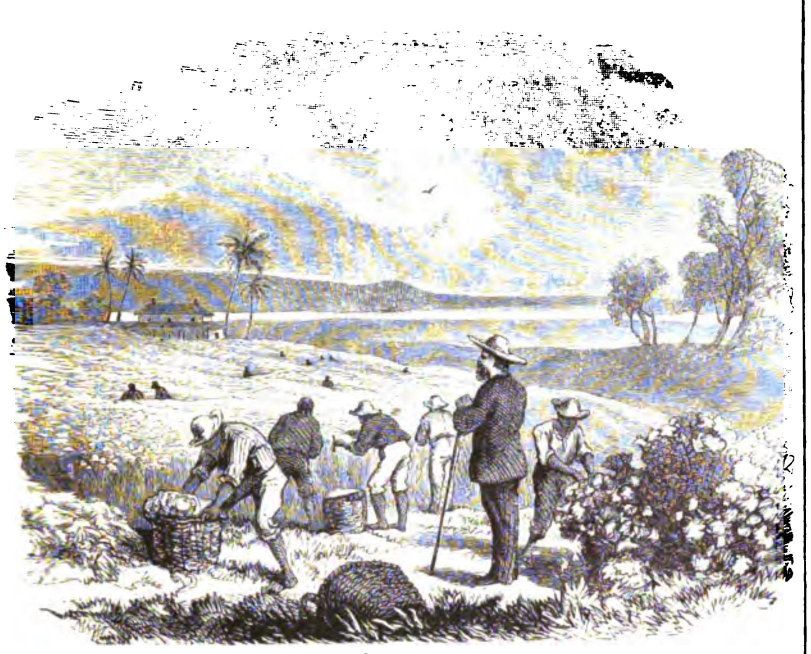
14. What are among the most important medicinal plants? State what is said respecting cinchona, opium, rhubarb, and aloes. 15. What are the chief narcotics? Give an account of tobacco, opium, hemp, the betel-nut, and coca. 16. What are the principal plants which furnish materials for clothing?

and in perfection of workmanship the finest productions of modern looms. The amount of cotton raised in the United States in 1860 was upwards of 5,000,000 bales of four hundred pounds each.



COTTON-FIELD.

Flax.—The flax-plant is but little affected by differences of soil and climate, and flourishes alike in the cold and temperate regions of Europe, throughout the New World, and in Asia and Africa. From the fibrous bark that surrounds its stem the thread is obtained, which from the remotest times has been used for making linen. It appears from the Bible that flax was grown in Egypt nearly four thousand years ago; and the microscope proves that the cloths in which the Egyptian mummies are wrapped are linen fabrics.

Hemp, which is a plant belonging to the nettle tribe, is a native of India and Persia, and is cultivated throughout Europe, especially in Russia, and to some extent in the United States. The fibrous bark, as in the flax-plant, furnishes the hemp of commerce, which is wrought into ropes and cables, and cloths of varied texture.

17. **Plants furnishing Dyes.**—Among the most valuable plants of this kind are *Indigo*, *Woad*, *Madder*, *Brazil-wood*, *Nicaragua-wood*, *Orchilla*, *Wold*, *Quercitron*, *Fustic*, and *Logwood*.

Indigo is obtained from several different species of plants, of which some grow in almost all parts of the torrid zone. The plants being placed in vats and covered with water, the coloring-matter is extracted by fermentation, and is the most beautiful and valuable of all the blue dyes. British India furnishes nearly three-fourths of all the indigo imported into Europe. Indigo has been raised to some extent in the Southern States.

Woad is cultivated in many parts of Europe, and grows wild in the southern portions. Its leaves yield a blue dye, which resembles that of indigo. Woad was used by the ancient Britons in staining their persons.

Madder is produced from a plant called the *Rubra tinctoria*, which is a native of the Levant and is successfully cultivated in France and Holland. The dye is obtained from the roots, and imparts a color of an orange-brown.

Brazil-wood grows extensively in the empire of Brazil; and from the heart of the tree a brilliant red dye is obtained.

Nicaragua-wood is found in the vicinity of the Gulf of Nicaragua, and yields a brighter and more delicate red dye than Brazil-wood.

Orchilla is a species of lichen that abounds in the Canaries and Cape Verd Isles, and affords a rich red dye. It is chiefly employed to give a brightness to materials dyed with other substances.

Wold is a plant nearly allied to the mignonette, but growing to the height of three feet. It flourishes spontaneously in England and in other parts of Europe, and yields, when boiled, a yellow powder which is much used for staining paper-hangings.

Quercitron is a yellow dye, which is extracted from the inner bark of the black oak.

Fustic is another yellow dye, which is derived from the wood of a species of mulberry-tree that grows wild in Brazil and the West Indies. It is much prized for its readily combining with other dyes.

Logwood is one of the most important black dyes, and is obtained from a tree which abounds on the shores of the Bays of Campeche and Honduras. The dye is extracted by boiling in water the chips of the heart-wood.

Besides the plants just mentioned, there are others that afford valuable dyes, such as Saffron, the Arnatto, Sumach-trees, and an East Indian plant whose roots furnish turmeric.

18. **Plants producing Oils, Resins, and Gums.**—The oils obtained from plants are either fixed or volatile. The former are extracted by pressure from the fruit and seeds; the latter are found in the flowers, leaves, wood, bark, and also in the seeds. Among the most valuable fixed oils are *Olive*, *Linseed*, *Palm*, *Cocoanut*, *Rape*, *Hemp*, and *Cotton* oils; while, of the volatile oils, *Turpentine* deserves especial mention. Among the chief resins and gums are the *Fir-Resin*, *Gum Copal*, *Gum Arabic*, and *Caoutchouc* or *India-Rubber*.

The olive-tree has been cultivated from the earliest antiquity, and celebrated for the fatness of its fruit, which in form somewhat resembles the plum. It is a native of the hot regions of Asia, whence it has been disseminated throughout the south of Europe and the north of Africa. It begins to bear when two years old, and produces to a very great age, yielding a rich fruitage when the trunk is reduced to a mere shell from internal decay. The oil which is extracted from the pulp and seeds of the fruit is much used for culinary purposes and largely employed in the arts.

Palm Oil is extracted from the kernels of the fruit of two species of palm which grow in several regions in Africa but abound especially in Senegal. It is much used in the making of soap and in perfumery.

Cocoanut Oil, obtained from the kernels of the cocoanut, is an excellent oil for burning, and is extensively employed in the arts.

Rape Oil comes from the seeds of a species of cabbage, and is much used in France.

Linseed Oil is expressed from the seeds of the flax-plant, and is especially prized by painters for its drying qualities.

Hemp and *Cotton Oils* are obtained by pressure from the seeds of those plants, and are of much value.

Oil of Turpentine exists, in combination with resin, in all the trees of the pine and fir tribe, and also in some others. When incisions are made in the tree, the turpentine flows from special cells in the wood where it is secreted, and the oil is separated from the resin by distillation. The same kind of trees also yields tar and pitch, which are regarded as imperfect turpentines. The yellow or pitch pine is particularly rich in tar, which is extracted by placing the split pine-wood in a kiln, and setting it on fire, when the tar, melted by

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Describe each of them. 17. Name the principal plants that produce dyes. State what is said in regard to each. 18. Name the principal vegetable oils, resins, and gums. What is said of the olive? How is palm-oil obtained? Cocoanut, rape, linseed, hemp, and cotton oils? Oil of turpentine?

the smothered heat, flows into reservoirs made to receive it. Pitch is tar deprived of its volatile oil. These four products—viz., oil of turpentine, resin, tar, and pitch—are of vast importance in the arts, supplying wants for which there are no adequate substitutes.

Gum Copal is obtained from a species of sumach which comes to perfection only in tropical climates. This gum, from its hardness and transparency, is greatly prized as a varnish.

Gum Arabic is derived from a species of acacia which abounds throughout Arabia and Central Africa. The gum exudes spontaneously from the trunk and branches of the tree, as in the cherry; but during the dry seasons incisions are made in the bark to obtain it. This gum is much used in calico-printing, to glaze the cloth so that the colors may not run together when impressed upon it. Other resins and gum-resins are much esteemed for their fragrance, such as Benzoin, Camphor, and Frankincense.

GATHERING CAOUTCHOUC.

Caoutchouc, or *India-Rubber*, is contained abundantly in the milky juice of many kinds of trees that grow in tropical regions. By making incisions in the bark, the juice exudes, which thickens, by exposure to the air, into caoutchouc. India-rubber was first brought to Europe about one hundred and sixty years ago, and until within about forty years was used simply for erasing pencil-marks. Since that time, discoveries have been made which have rendered caoutchouc one of the most important and valuable substances employed in the arts. Dissolved in ether and naphtha, it is spread like a varnish over cloths, rendering them impervious to water; and fabrics of this kind are now manufactured to a great extent. Combined with sulphur, it forms vulcanized rubber, which is employed in the construction of an infinite variety of articles both for ornament and use. Nearly all the furniture of a parlor has been constructed from this material.

19. **Woods.**—Within the circle of the arts, materials are needed which possess special properties, either singly or combined, and are capable of being easily wrought into any required form. This universal and imperative want is supplied by the forests of the globe, and can be provided for in no other way.

The *Pine* is distinguished for softness, lightness, and durability, and, though deficient in strength, is extensively employed for building purposes, and for the masts of ships.

The *Oak* possesses great durability, and is exceedingly valuable for ship-timber and wherever great strength is required.

The *Ash* is light, straight, elastic, and durable, and is used where strength is needed and weight avoided.

Mahogany, on account of the beauty of its grain and color, its hardness, and the invaluable property which it possesses of not shrinking or cracking for a great length of time, excels all other woods for cabinet-ware.

Rosewood and *Black Walnut* possess similar beauties and the same property, and are largely used in the construction of furniture. In addition to these, a great variety of rich and beautiful foreign woods are employed for ornamental purposes.

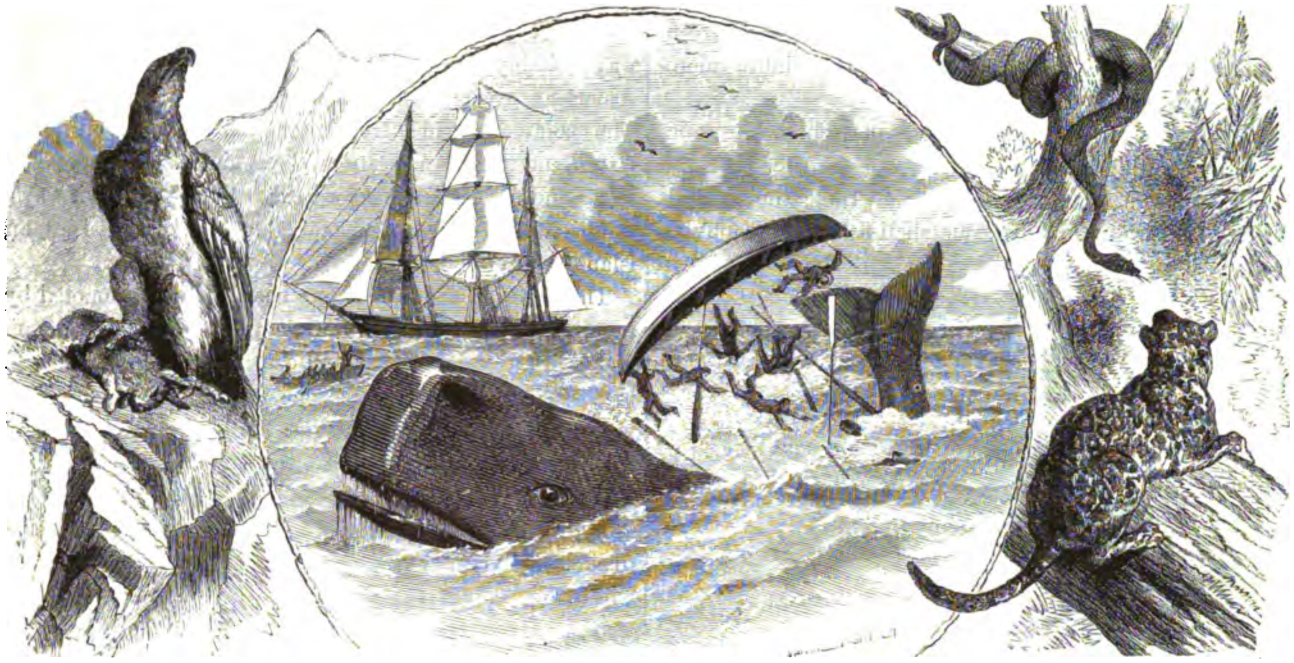
The *Bamboo*, which belongs to the tribe of grasses, is an immense cane that abounds in the tropical regions, and grows to the height of sixty and even one hundred feet. It is an extremely useful plant, and subserves a great variety of purposes. The inhabitants of many parts of India build their houses almost wholly of bamboo, and make all kinds of furniture and utensils with it in a very ingenious manner, fabricating tables, lounges, mats, baskets, boxes, cups, tubs, and a great variety of other articles. It furnishes, also, an excellent material for the masts and framework of boats, and its woven strips form the cordage and sails. With its lightest sprouts the savage makes his arrows, with its larger stems his bows, and with its fibres his bow-strings; while a slender shoot, with its hardened point, arms him with a lance.

Besides the various plants just described, there are many others which are indirectly useful to man, such as the grasses and other forms of vegetation which support those animals that subserve his wants.

20. **Fuel.**—All plants are combustible; and the immense stores of fuel which man requires come from the vegetable kingdom. The forests that now shadow the soil furnish wood and charcoal; and the floras of former eras have stored the globe with vast beds of coal and peat.

21. **Proofs of Design.**—"It would be wrong," to use the eloquent words of Carpenter, "not to contemplate the important inferences which may be drawn from the vegetable kingdom in regard to the Power, Wisdom, and Goodness of the Almighty Designer. His power is remarkably displayed in the immense variety of products elaborated out of three simple elements,—viz., oxygen, hydrogen, and carbon; his wisdom is strikingly evinced in diffusing these products over the whole globe; and his goodness is peculiarly manifested in the adaptation of these products to the use of man." Moreover, the vegetable world ministers most bounteously to the gratification of our more refined senses and to the wants of our higher nature. Balsams and resins yield their grateful fragrance, and flowers and blossoms in every habitable clime fill the air with delicious odors. The floras of the globe present to the eye countless and varied forms of grace and beauty, and glow with such rich and delicate combinations of tint and hue as no art can rival, and which it is among its highest attainments simply to imitate.

What is said of gum copal? Of gum Arabic? Of caoutchouc? 19. What is said of the use of woods in the arts? What of the bamboo? Are there other plants, besides those just mentioned, that are indirectly useful to man? 20. Whence is fuel derived? 21. State the proofs of design exhibited by the vegetable kingdom.



IMPERIAL EAGLE. WHALE-FISHERY. BOA.—TIGER.

CHAPTER II.

GEOGRAPHICAL ZOOLOGY.

1. Geographical Zoology treats of the general divisions of the animal kingdom, and of its distribution and diffusion over the world.

The globe is as rich in animal as in vegetable life. The mountains and plains, the forests and rivers, are filled with animated forms; innumerable birds and insects people the air; and the ocean throughout its depths is instinct with vitality, from the huge whale to the minute microscopic organisms that swarm in the polar seas.

2. **Distribution.**—As animal life is intimately connected with vegetable existence, it is not surprising to find that both are governed by the same general laws of distribution. The condition of animals is influenced by the nature of the climate to which they are subjected, and of the food which they eat. Distinct races are more or less confined each within its own geographical region; and if transported beyond this, the animal lives or dies, according to its power to adapt itself to the new conditions of existence. From the equator to the poles, and from the sea-level to the snow-line, the various tribes of terrestrial animals have their respective localities where their growth and development are best promoted; and in the ocean the same law prevails. The animal life of any region is termed its *fauna*.

The fauna of the tropic climes is as exuberant as its flora; and not only are the species of animals more numerous than in other latitudes, but the largest forms and the highest beauty are here attained.

The torrid zone is the home of the elephant, the hippopotamus, the rhinoceros, and the graceful giraffe; the ostrich stalks over its deserts, and the huge boa lurks in its dense marshes. Birds of the most brilliant plumage, as the parrot, humming-bird, and toucan, gleam amid its forests; while insects as dazzling as gems, like the diamond beetle of Brazil, sport in the air.

The temperate climes are the abode of the domesticated and useful animals, such as the horse, ox, sheep, and dog; and reptiles and beasts of prey are less numerous and powerful than in the equatorial regions. New types of birds and beasts here abound, such as the eagle, turkey, and pheasant, and the wolf, fox, beaver, and kangaroo, which are smaller and less active than those that are native to the tropical climes, and are also inferior to them in beauty.

The polar faunas comprise few species, but numerous individuals, and the birds and beasts are dull and sombre in hue, or else of a snowy white. The reindeer, polar bear, sable, and ermine, are peculiar to this region; reptiles are unknown; and the numerous sea-fowls migrate hither from the cool temperate climes.

Different faunas are likewise found at different heights above the sea. At the bases of the lofty mountains of the globe, the animals peculiar to the respective latitudes of these regions are found; but as we ascend, peculiar types of animal life characterize the varying altitudes. Thus, on the Alps the chamois and steinbok have their home between the upper limit of trees and the snow-line; and the llama dwells in a similar region among the rocky heights of the Andes. In Asia the yak thrives amid the snows of the Himalayas even during the winter, and retreats in the heat of summer to the snowy regions. Birds and reptiles are controlled by the same law: the green macaw is never found in the Andes above the limits of 3000 feet; while the condor builds its nest on the inaccessible peaks of those lofty mountains. The crocodiles and boas on the Western Continent appear to be limited to the height of about 3000 feet.

As in the vegetable kingdom, animal life decreases in amount on the land with the increase of latitude; but in the ocean this law is reversed as respects the higher organizations. In the tropic seas many genera and species of fish and shell-fish are found; and the marine life of this region is distinguished for its brilliant colors. Here is the home of the shark; for in the Pacific this terrible monster is said to be unknown beyond the tropics. In the seas of the higher latitudes, life has less variety of species, but the individuals are far more numerous; for it is only in their cool waters that the herring, cod, mackerel, haddock, shad, and salmon, and other fishes prized for food, are developed in such amazing numbers and perfection, and it

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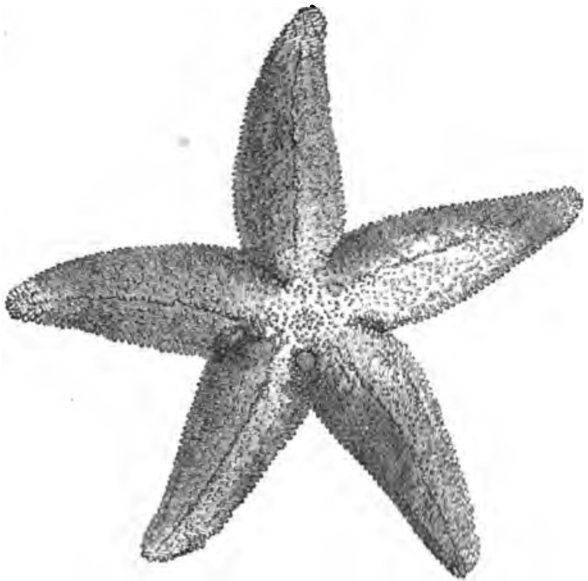
What is the subject of Chapter II.? 1. Of what does Geographical Zoology treat? What is said of the richness of the globe in animal life? 2. What is said respecting the distribution of animals? Describe the faunas of the tropic, temperate, and polar climes. Do different faunas likewise exist at different heights above the sea-level? Give the illustrations. What is said of the animal life of the ocean as respects latitude? Give the illustration.

is to these seas that the true whale is confined. So prolific is the polar ocean, that Captain Scoresby estimates one-fourth of the Greenland Sea to contain no less than 23,000,000,000,000 minute microscopic animals of one species.

Marine life also varies with the depth, both in respect to species and numbers. Between high and low water are found such shell-fish as the periwinkle, muscle, and clam; and below these the water is crowded with star-fish, sea-urchins, various shell-fish, and zoophytes.



STAR-FISH.

Lower still, to the depth of from fifteen to fifty fathoms, and existing in greater abundance and variety, live numerous arborescent or tree-like animals, sponges, voracious mollusks, and huge radiata. Beyond these, to the depth of six hundred feet, are found the sponges, corals, mollusks, and other forms that inhabit deep waters. Life also occurs in the abysses of the ocean; for living creatures have been taken up by the sounding-line from the depth of 6000 feet. A living star-fish was even brought up from the depth of 7560 feet, by Dr. Wallack, in Baffin Bay.

3. **Extent and Modes of Diffusion.**—Some races of animals have the power of adapting themselves to almost every clime; while others are confined to their original abodes, or perish if they pass far beyond their borders. Thus, on the one hand, the dog is the companion of man in all his migrations, and the crow is said by Captain Basil Hall to be met with in every climate. On the other hand, the tsetse, a fly whose bite is certain death to the ox, horse, and dog, is confined to a certain district in South Africa, marked by no visible boundary, but which is so definite that if a horse crosses it he dies. The reindeer suffers from heat at St. Petersburg; and the ape tribe perish from cold in the temperate climes. "Yet these wonderful adaptations of the structure of animals to the circumstances in which they are placed prove that their distribution is the result of Almighty design, a part of the great symmetrical whole of creation."

The dispersion of animals from the region where they have originated has been effected by their own powers of motion, the agency of man, and by the currents of the air and ocean. The wild duck and pigeon fly from four hundred to five hundred miles a day. Insects and land-birds, either driven by the winds or journeying of their own accord, have alighted on the spars of vessels far out of sight of land. "A live boa-constrictor," says Milner, "was once found on the isle of St. Vincent, coiled round the trunk of a cedar-tree, which was probably carried out to sea by the flood of one of the vast South American rivers and borne by the ocean-current to the island." The polar bear has frequently been conveyed on floating ice from Greenland to Iceland; and wolves and foxes have been found far from land on the drifting ice-field. In these various ways has animal life been diffused from the main land to adjacent isles, and from one island-group to another.

The diffusion of animals has been greatly promoted by man, who, in all his migrations, has carried with him those domestic animals which are useful for labor and contribute to his sustenance and comfort. Thus, the ox, horse, sheep, and pig have accompanied the march of civilization. The vast herds of cattle and wild horses that roam over the plains of South America are the descendants of European breeds.

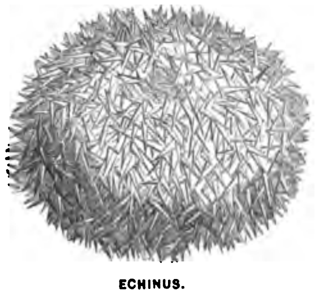
In Australia, the sheep introduced by the colonists have multiplied to such an extent that wool has become an important article of export, while the song of the nightingale and lark is now heard amid its woods. Upon the isles of the Pacific the cow, goat, and pig have been successfully introduced by European navigators and missionaries.

Other races of animals have also followed man of their own accord, such as the rat and mouse. The brown rat of Persia, which was introduced into Europe about the year 1727, has been conveyed, in the holds of ships, to almost every part of the world.

On the other hand, man has greatly restricted the domain of both dangerous and useful animals. Thus, the Asiatic lion, which once roamed throughout Asia Minor, Palestine, and Macedonia, is now confined to the regions beyond the Euphrates. The wild bull of Europe, which formerly abounded in the forests of Gaul and Germany, now exists in scanty numbers amid the woods of Poland. The bear, wolf, and beaver, centuries ago, abounded in Great Britain. The last bear was killed in 1057 A.D., and the last wolf near the close of the seventeenth century.

In the United States, the buffalo has retreated from the Atlantic States to the foot of the Rocky Mountains. The beaver and other fur-bearing animals have also withdrawn from their old abodes, and the hunter now seeks them in the deeper recesses of the forests.

Such has been the unremitted persecution of the whale, in the great demand for oil, that but few can now be found, and, in this country, the seaports formerly supported by this fishery have fallen into decay.



ECHINUS.

Same, seen from above, with spines removed.

4. **Animal Kingdom,—Classification and Extent.**—The animal kingdom, according to distinguished naturalists, such as Cuvier, Agassiz, and others, is divided into *Branches*, *Classes*, *Orders*, *Families*,

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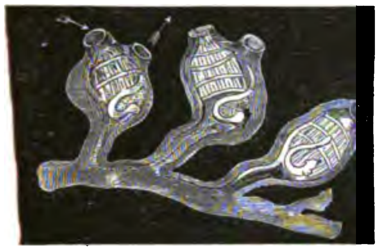
What is stated respecting marine life in respect to depth? Give the illustrations. 3. What is said in reference to the dispersion of animals? Give the illustrations. Is there not, however, a wonderful adaptation of the structure of animals to the circumstances in which they are placed? By what methods has the diffusion of animals been effected? Give the illustrations. What is said of the agency of man? Cite the proofs. Has man, on the other hand, greatly restricted the domain of dangerous and useful animals? Give the illustrations.

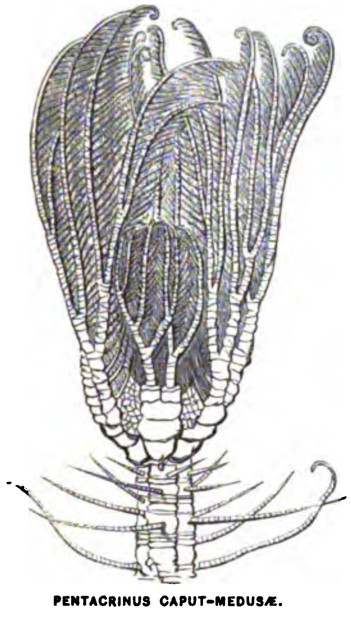
Genera, and *Species*. Each branch has been subdivided into classes, classes into orders, orders into families, families into genera, and genera into species. These divisions and subdivisions are not arbitrarily made, but are founded upon the natural distinctions existing in animals.

The animal kingdom embraces about 250,000 known species; but these are not all; for an eminent naturalist, some years ago, estimated, from acknowledged facts and principles, that the number of existing species amounted to 577,600. This multitude of living creatures is divided into four branches,—namely, Mollusks,[1] Radiates,[2] Articulates,[3] and Vertebrates.[4]

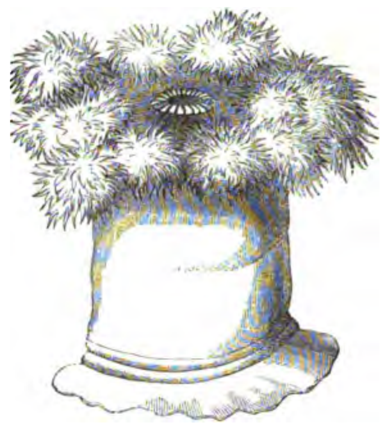
5. **Mollusks.**—These animals are of a soft texture, without any skeleton, and their bodies in most cases have the power of forming a shelly covering. To this branch, which is chiefly aquatic, belong the snail and squid, the nautilus, with its many-chambered shell, the clam, the oyster, and the wing-footed mollusks which swarm in such numbers in the polar seas that they constitute the principal food of the right whale. In this division is also found the curious little animal called the social ascidian, which has the shape and texture of a leather bottle and grows in groups and clusters. This branch includes 10,000 species.


SOCIAL ASCIDIAN.

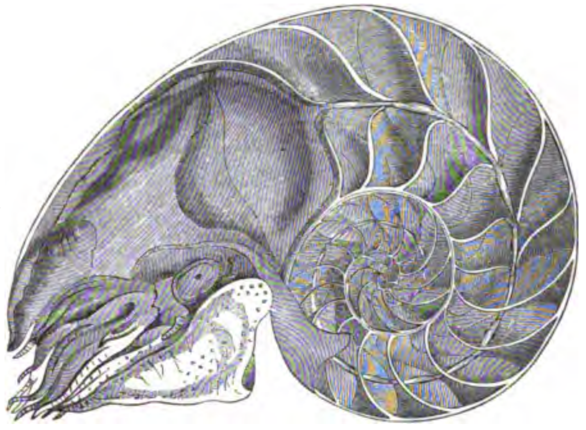
6. **Radiates.**—Radiates have the parts of their bodies arranged in a circular manner around a centre, so as to present a radiated appearance like the spokes of a wheel. Of this form are the well-known star-fish, and the prickly echinus, or sea-urchin, whose shell is a most exquisite and delicate structure. It is formed, in a moderate-sized echinus, of nearly 600 different plates, admirably fitted to each other; and these are pierced with about 1860 minute holes, through which delicate sucker-like feet are protruded at the will of the animal. To this branch belong also the crinoids, or lily-formed animals, the umbrella-shaped medusæ, the zoophytes, or plant-animals, including the sea-anemone, which, like a starry flower, blooms amid the waves, and that wondrous insect that lays the foundation of islands on the floor of the ocean and spreads the coral forest throughout its depths. This branch comprises about 10,000 species.


PENTACRINUS CAPUT-MEDUSÆ.

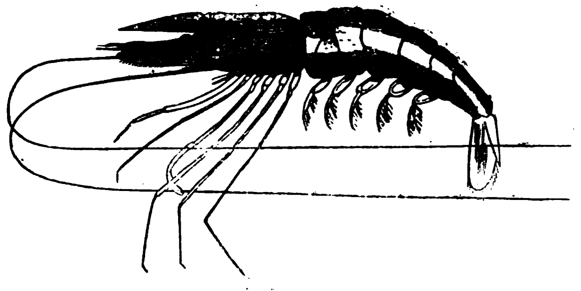
Infusoria.—This name is given to numerous forms of microscopic animalcules, on account of their having being first found in vegetable infusions. They are classed by some writers among the radiates, but in truth are confined to no one branch; for so high is the organization of the *wheel-animals* that they have been placed among the articulates.


SEA-ANEMONE.—(Expanded.)

The searching investigations of naturalists have shown that the infusoria are most widely diffused over the globe; that they abound in all waters, and exist in the fluids and tissues of animal and vegetable bodies. They are extremely tenacious of life, being found alive in the floating ice of the Arctic Ocean, while they retain their vitality under a temperature of 248° Fah. Many species of these organisms are encased in shells, consisting for the most part of lime and flint, which remain for ages after the animal has perished. To such an extent have the infusoria abounded that entire ranges of hills and masses of rock are found composed of these minute envelopes. Bog-iron is made up of microscopic iron shells; forty thousand millions of organic forms are contained in a cubic inch of the tripoli rock of Bilin; and the cities of Richmond and Petersburg rest upon beds of marl from twelve to twenty-eight feet thick, full of curious infusorial structures. Shells of this kind have also been found in volcanic ashes.


NAUTILUS.

7. **Articulates.**—This branch includes those animals whose bodies are composed of joints and rings, as the lobster, crab, shrimp, barnacle, and earthworm. Here are also found the serpula, a marine animal remarkable for its elegance and beauty, and the sea-mouse, which, glowing with the richest prismatic colors, vies with the humming-bird in the splendor of its hues.


COMMON SHRIMP.

Within this division, likewise, are included the various forms of insect life, such as the gorgeous butterflies, the beetles with their polished shards, the vengeful scorpion, the hideous spider, the centipede, dreaded for its envenomed bite, and the locust, whose swarming myriads desolate the fertile fields of the East. Those useful creatures, the honey-bee, silkworm, ant, and coccus, whose body furnishes a brilliant red dye termed cochineal, are also classed with Articulates. This branch comprises about 200,000 species.

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[1], [2], [3], [4]. From the Latin words *mollis*, "soft;" *radius*, a "ray;" *articulus*, a "joint;" and *verto*, to "turn."

4. How is the animal kingdom classified? What is said of the extent of the species? What are the four branches that include all animals? 5. Describe Mollusks. What is the number of species comprised in this branch? What animals belong to this branch? 6. Describe Radiates. What radiates are mentioned? How many species does this branch contain? What are Infusoria? To what branch do they belong? State what is said of their diffusion. What of their remains? 7. What are Articulates? Describe those that are mentioned. How many species does this branch comprise?

8. **Vertebrates** are distinguished for having a jointed backbone, or vertebral column. They rank the highest of all animals in their organization; and man himself belongs to this branch. It is divided into five classes,—*Fishes*, *Batrachians*, *Reptiles*, *Birds*, and *Mammalia*.

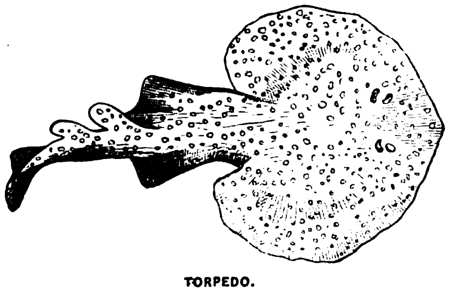
9. **Fishes,** which form the lowest class of Vertebrates, possess the characteristics of being cold-blooded and of breathing by the gills. Certain species are found only within particular waters; while others roam widely through the sea. Some are solitary, and others gregarious and migratory. The flying-fish and gilt-head never pass beyond the parallel of forty degrees. The shark is a native of the tropic seas; though it is found as far north as Scotland. One species—the white shark—grows to an immense size, being sometimes from twenty-five to thirty feet long, and having a mouth sufficiently capacious to receive the body of a man. Cod, herring, pilchards, mackerel, and sardines are migratory, and swim the sea in prodigious numbers.

On the coast of Norway the cod arrive at the beginning of the year, in shoals many yards thick, and so crowded together that the sounding-lead can hardly pass between them. The Grand Bank of Newfoundland for an extent of four hundred and fifty miles is the favorite resort of this valuable fish; and millions are caught here every year.

The herring, issuing from the polar seas, resorts to the coasts of Western Europe, Kamtschatka, and the Aleutian Isles, and is found along the eastern American shores as far south as the Carolinas. In such vast numbers do they congregate that they sometimes cover the sea in shoals many square leagues in extent and several hundred feet in thickness.

The salmon is also migratory, going from the sea up the rivers to spawn. This splendid fish frequents the Columbia River in such immense numbers that they form the chief article of winter food for the neighboring Indian tribes.

The fish which are used by man as food dwell in the shallow coast-waters; and a low temperature improves their flavor. To the cold polar current along the shores of the United States Lieutenant Maury attributes the excellence of the fish with which our Atlantic cities are supplied; and the Antarctic cold current that sweeps along the Pacific shores of South America causes in like manner the coast-waters to teem with rich and valuable fish.



TORPEDO.

A few kinds of fish, as the torpedo and *Gymnotus electricus*, have the power of giving shocks of electricity.

The number of species of fish is estimated at about 12,000.

Batrachians,[1] which are cold-blooded animals, include three orders,—namely, Frogs, Salamanders, and Cæcilian or Snake-like Batrachians.

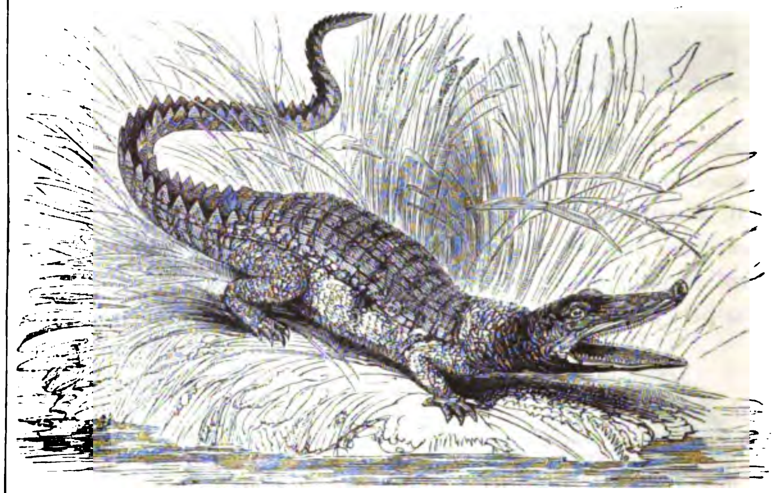
Frogs constitute a link between the land and water animals,—approaching nearest to the latter in their nature, as they breathe through lungs when full-grown. They are found in almost every part of the globe; and one species exists near the Alpine snow-line. The tree-toad is included in this order.

Salamanders differ from frogs in having tails and feet. Some of them are aquatic, and others live on the land.

Cæcilians, which are all natives of warm countries, have a round, cylindrical body, without neck or feet, and move in the manner of serpents. They form a connecting link between reptiles and frogs.

10. **Reptiles.**[2]—The class of Reptiles, which consists of cold-blooded animals, is divided into four orders, three of which—the Saurians, Chelonians, and Ophidians—deserve especial notice.

Saurians[3] are found throughout the tropical and temperate climes; and to this order belong crocodiles and lizards. There are three families of the former,—the true crocodile, which is found in Africa, India, and the hottest parts of America; the gavial, which infests the Ganges; and the alligator, which occurs only in the Western Hemisphere. This formidable reptile abounds in the bayous and lagoons of the Gulf States, and is so ferocious as to attack men and animals. Among the *lizards* is the iguana, which lives in tropical America and in Africa, and is a delicate article of food.



ALLIGATOR.

Chelonians[4] comprise all turtles and tortoises, whether inhabiting the land or water, and are distinguished from other reptiles by being enclosed within an upper and a lower shell, each of which is formed of several pieces.

Some of the land-tortoises are of great size,—one species, belonging to the Galapagos Islands, attaining a weight of from five hundred to six hundred pounds. The largest species of fresh-water turtle is found in the Ganges, where it is not uncommon for one of them to weigh two hundred and fifty pounds. The green turtle, so much prized for food, lives in the Atlantic within the tropics: they are often six or seven feet long and reach the weight of from six hundred to seven hundred pounds. Tortoise-shell is obtained from the hawk's-bill turtle, which is found in different parts of the Indian Ocean.

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[1] From the Greek word *batrachos*, a "frog."

[2] From the Latin word *repto*, to "crawl."

[3], [4] From the Greek words *saura*, a "lizard," and *chelone*, a "tortoise."

8. How are the Vertebrates distinguished? Into what classes is this branch divided? 9. What are the characteristics of Fishes? State what is said respecting them, and describe those which are mentioned. How many species of fish are known? What are Batrachians, and how many orders does this class include? Describe them. 10. What classes of Reptiles are especially to be noticed? Describe the animals mentioned under each class.

Ophidians[1] comprehend every kind of snake; they are found throughout the torrid and temperate zones, but especially infest the former. Some of the species are venomous; but the greater part are innoxious,—the ratio of the former to the latter being about one to five. The largest snakes are the boas and pythons. The former are found only on the Western Continent, and the latter on the Eastern. The boa, varying from nine to fifteen feet in length, abounds in the dense forests of South America, where, lurking amid the trees, it watches for its prey, dropping suddenly upon it as the animal passes beneath, and, after crushing it to death in its powerful folds, swallows it entire. The python is the largest of all serpents in the Eastern World, growing, according to Dr. Livingstone, to the length of from fifteen to twenty feet. It seizes, kills, and devours its prey in the manner of the boa, living chiefly upon small animals; but occasionally the steinbok and pallah fall its victims.

Neither of these kinds is poisonous. Most deadly among the poisonous snakes are the cobra di capello and the rattlesnake. The cobra is found from Malabar to Sumatra, and in some parts of Africa, and is so venomous that on one occasion, when the tips of the ears of a wild hog were pressed between two boards and the snake was made to bite them, though the wounded parts were cut off immediately, the animal died in a few seconds. The rattlesnake is found only in America, and is so called because the tip of its tail is formed of several loosely-jointed bones, which the animal rattles when it is aroused or irritated.

The Batrachians and Reptiles include about 2000 species.

11. **Birds.**—Birds are found all over the globe. Arctic voyagers have seen them passing northward beyond the highest latitudes they themselves have been able to attain, and from the sea-level they soar far beyond the snow-line of the loftiest equatorial mountains. Most species are confined to particular regions; but there are exceptions to this law. A great similarity exists between the birds of the northern regions of the Old and New Continents; but in the tropical and southern temperate zones of America, Asia, and Africa they are entirely different. Many birds are migratory, passing the winter in one country and the summer in another. Of this class are geese, swallows, and pigeons. Some migrate singly, others in groups, and some in immense flocks. A flock of pigeons was once seen by Alexander Wilson, which was a mile in breadth, and, from the time occupied in its passage, was estimated to be 240 miles long. It was computed to contain more than 2,000,000,000 birds.

Birds are divided into seven orders,—namely, *Raptores*[2] (Birds of Prey), *Insessores*[3] (Perchers), *Scansores*[4] (Climbers), *Rasores*[5] (Scratchers), *Cursores*[6] (Runners), *Grallatores*[7] (Waders), and *Natatores*[8] (Swimmers). The first five orders are land-birds; the others, water-birds. They are all warm-blooded, and comprise between 6000 and 7000 species.

To the order of the *Raptores* belong vultures, falcons, and owls. Chief among the vultures is the condor, which measures when full-grown, according to Humboldt, fifteen feet from tip to tip of its outstretched wings. It dwells exclusively amid the Andes, yet, under pressure of hunger, sometimes seeks the sea-shores for food; but here it cannot long remain, on account of the heat, and soon returns to its cold mountain-home. Of the falcons, the imperial eagle is the largest. It is found amid the high mountains of Central Europe, and is noted for its strength and courage. The bald eagle is the most distinguished for its beauty of all the North American species, and has been adopted as the emblem of our country.

Among the *Insessores* are classed the singing-birds, such as the lark, oriole, canary, mocking-bird, and thrush. The bird of Paradise, the kingfisher, and the beautiful group of humming-birds also belong to this group.

CONDOR; IMPERIAL EAGLE; PENGUIN.

The mocking-bird, a native of the Southern States, is described by Herschel as the "very embodied spirit of woodland melody, which, besides possessing an unrivalled song peculiar to itself, imitates in perfection, and even surpasses, that of every other species."

The birds of Paradise, which are unsurpassed for their rich and brilliant plumage, are inhabitants of New Guinea and the neighboring islands. The humming-bird is found only in the Western Continent: no more than four species belong to North America, while in tropical South America three hundred species exist, varying from the size of a wren to that of an humble-bee. They are chiefly confined to tropical climes; but some species are not thus restricted; for humming-birds have been seen off Terra del Fuego, and in the cold latitude of Behring Strait.

Under the order of *Scansores* are included parrots, toucans, woodpeckers, and cuckoos.

Parrots are remarkable for their beautiful plumage and their facility in imitating sounds and words. They swarm in the tropical forests of Africa and Asia; while no less than forty species are natives of South America. These birds are chiefly confined to the torrid zone, but in the Western Hemisphere range from the Strait of Magellan to the 42d degree of north latitude, and are found on the Eastern Continent as far as the 56th degree of south latitude. Toucans are noted for their large, thin bills, and for their splendid plumage of mingled black, orange, and scarlet: they are indigenous to the tropical climes of South America, and abound in the dense forests of Brazil.

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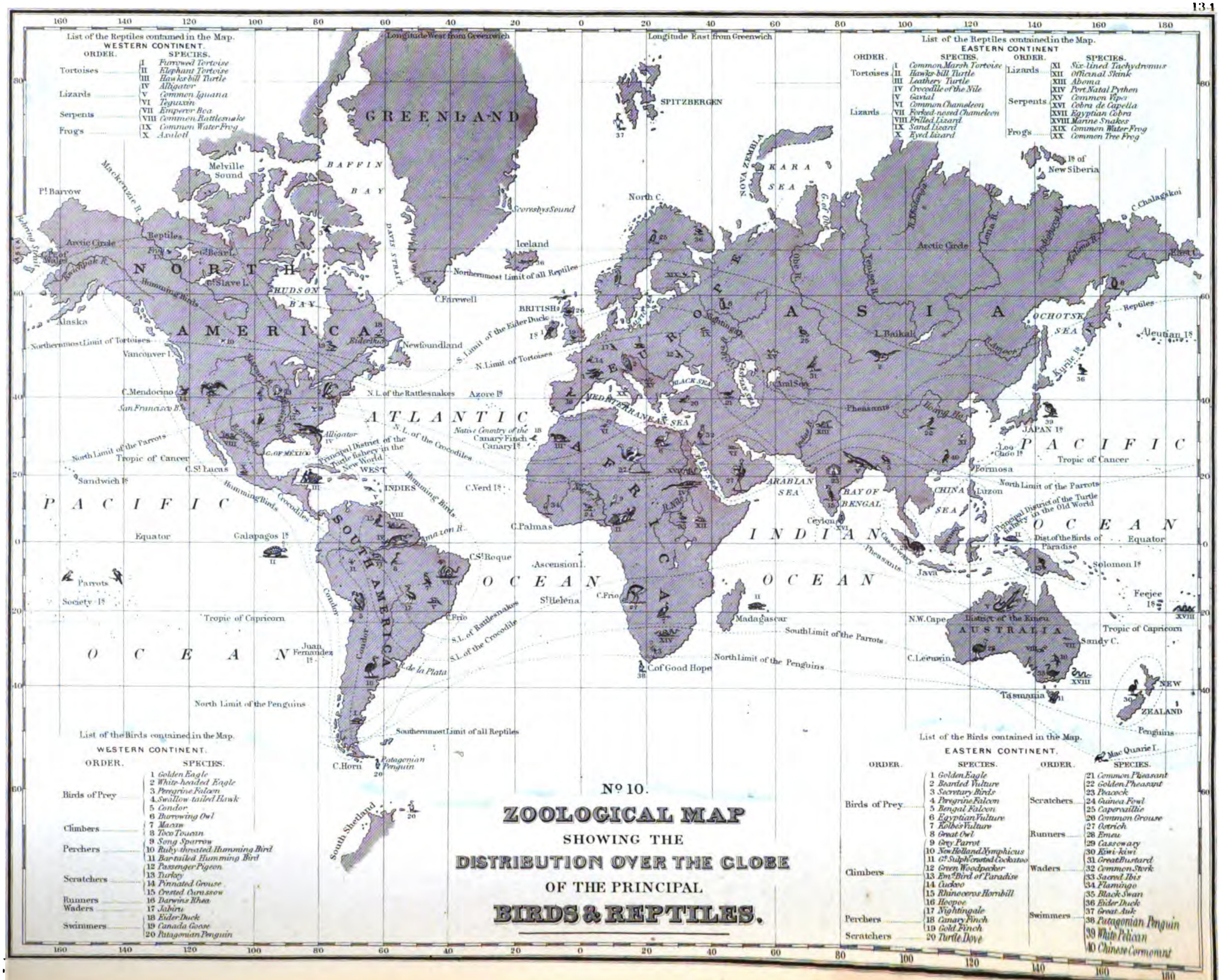
[1] From the Latin word *ophis*, a "snake."

[2], [3], [4], [5], [6], [7], [8] From the Latin words *rapto*, to "seize," *insido*, to "perch," *scando*, to "climb," *rado*, to "scratch," *curso*, to "run about," *grallator*, "one who goes on stilts," and *nato*, to "swim."

How many species do the Batrachians and Reptiles number? 11. What is said respecting the distribution and habits of Birds? Into how many orders are birds divided? Mention them. Why are they so called? What orders are land-birds, and what water-birds? Describe the Raptores, Insessores, and Scansores.



List of the Reptiles contained in the Map.
WESTERN CONTINENT.

ORDER.	SPECIES.
Tortoises	I *Furrowed Tortoise*
	II *Elephant Tortoise*
	III *Hawks bill Turtle*
Lizards	IV *Alligator*
	V *Common Iguana*
	VI *Teguixin*
Serpents	VII *Emperor Boa*
	VIII *Common Rattlesnake*
Frogs	IX *Common Water Frog*
	X *Axolotl*

List of the Reptiles contained in the Map.
EASTERN CONTINENT

ORDER.	SPECIES.	ORDER.	SPECIES.
Tortoises	I *Common Marsh Tortoise*	Lizards	XI *Six-lined Tachydromus*
	II *Hawks-bill Turtle*		XII *Officinal Skink*
	III *Leathery Turtle*		XIII *Aboma*
	IV *Crocodile of the Nile*		XIV *Port Natal Python*
	V *Gavial*	Serpents	XV *Common Viper*
	VI *Common Chameleon*		XVI *Cobra de Capella*
Lizards	VII *Forked-nosed Chameleon*		XVII *Egyptian Cobra*
	VIII *Frilled Lizard*		XVIII *Marine Snakes*
	IX *Sand Lizard*	Frogs	XIX *Common Water Frog*
	X *Eyed Lizard*		XX *Common Tree Frog*

List of the Birds contained in the Map.
WESTERN CONTINENT.

ORDER.	SPECIES.
Birds of Prey	1 *Golden Eagle*
	2 *White-headed Eagle*
	3 *Peregrine Falcon*
	4 *Swallow-tailed Hawk*
	5 *Condor*
	6 *Burrowing Owl*
Climbers	7 *Macaw*
	8 *Toco Toucan*
Perchers	9 *Song Sparrow*
	10 *Ruby-throated Humming Bird*
	11 *Bar-tailed Humming Bird*
Scratchers	12 *Passenger Pigeon*
	13 *Turkey*
	14 *Pinnated Grouse*
	15 *Crested Curassow*
Runners	16 *Darwins Rhea*
Waders	17 *Jabiru*
Swimmers	18 *Eider Duck*
	19 *Canada Goose*
	20 *Patagonian Penguin*

Nº 10.
ZOOLOGICAL MAP
SHOWING THE
DISTRIBUTION OVER THE GLOBE
OF THE PRINCIPAL
BIRDS & REPTILES.

List of the Birds contained in the Map.
EASTERN CONTINENT.

ORDER.	SPECIES.	ORDER.	SPECIES.
Birds of Prey	1 *Golden Eagle*	Scratchers	21 *Common Pheasant*
	2 *Bearded Vulture*		22 *Golden Pheasant*
	3 *Secretary Birds*		23 *Peacock*
	4 *Peregrine Falcon*		24 *Guinea Fowl*
	5 *Bengal Falcon*		25 *Capercaillie*
	6 *Egyptian Vulture*		26 *Common Grouse*
	7 *Kolbe's Vulture*	Runners	27 *Ostrich*
	8 *Great Owl*		28 *Emeu*
Climbers	9 *Grey Parrot*		29 *Cassowary*
	10 *New Holland Nymphicus*		30 *Kiwi-kiwi*
	11 *G^t Sulph^r crested Cockatoo*	Waders	31 *Great Bustard*
	12 *Green Woodpecker*		32 *Common Stork*
	13 *Em^d Bird of Paradise*		33 *Sacred Ibis*
	14 *Cuckoo*		34 *Flamingo*
	15 *Rhinoceros Hornbill*	Swimmers	35 *Black Swan*
	16 *Hoopoe*		36 *Eider Duck*
Perchers	17 *Nightingale*		37 *Great Auk*
	18 *Canary Finch*		38 *Patagonian Penguin*
	19 *Gold Finch*		39 *White Pelican*
Scratchers	20 *Turtle Dove*		40 *Chinese Cormorant*

Drawn & Engraved by J. M. Atwood, Philadelphia.

The order of the *Rasores* is more extensively represented in the **Eastern** than in the Western Continent, and includes such birds as the **peacock**, pheasant, quail, grouse, domestic fowl, and pigeon.

ORIOLE; PEACOCK; BIRD OF PARADISE.

The peacock, renowned for its gorgeous plumes, belongs to Southern Asia; and two species live wild in the groves of India and Ceylon. The pheasant is also Asiatic in its origin, and is scarcely less beautiful than the peacock. It is, however, more widely diffused than the latter, and comprises within its family some of the most splendid Eastern birds, such as the gold and silver pheasants of China. The turkey is a native of North America, and ranges from Ohio and Missouri to the Isthmus of Panama. It was first introduced into England in 1526, and is now domesticated in all parts of the world. Pigeons belong both to the Old and the New World. In the Western States they congregate in such vast multitudes at their roosting-places that the limbs of the largest trees, throughout extensive localities, are broken down by their weight, and the forest appears as if desolated by a storm.

The birds which are ranked under the order of *Cursores* are few in number, and belong to the family of the ostrich, embracing the ostrich proper, the emu, cassowary, and apteryx. They are birds of great size, and have comparatively short wings, which assist them in running but are useless for flight.

OSTRICHES.

Of all ostriches, the African species is the largest, being from seven to nine feet in height. It inhabits the sandy deserts of Africa, and is believed to be the fleetest of all running creatures. Its stride, when pursued, is from eleven and a half to fourteen feet in length. Dr. Livingstone says that so fast does the ostrich run that, generally, one's eye can no more follow the legs than it can the spokes of a carriage-wheel in rapid motion; and he estimates its speed at twenty-six miles an hour. Formerly this species extended throughout Asia Minor, Persia, and Southern and Eastern Asia, but is now nowhere found in this continent, except in Arabia. The ostrich is hunted for the sake of its beautiful plumes.

The cassowary, which is a native of Java, is about five and a half feet in height, and is covered with a plumage that resembles coarse hair. It runs with a bounding motion, far surpassing the speed of a horse. The emu, which is found only in Australia, is a swift-footed bird, larger than the cassowary, having a height of more than seven feet. The apteryx, which lives only in New Zealand, is about the size of a goose, with wings one and a half inches long. This genus is nearly extinct.

Describe the Rasores. State what is said of the Cursores.

The *Grallatores* are noted for the stilt-like legs and long necks and bills, by which they are enabled to wade and to obtain food in shallow water. Such are the stork, heron, plover, snipe, and flamingo. The stork is a tall and stately bird, which, on account of its services in destroying noxious insects and reptiles, has in many places been protected by law; and by the ancients it was considered a crime to kill it. The common stork of Europe migrates to Asia Minor, where it spends the winter. A stork, in 1846, was caught on one of the mountains of Palestine, and around its neck was a silver locket, enclosing a letter dated from a castle in Germany where the bird had its nest.

The flamingo is one of the most remarkable birds of this order. Its plumage is a brilliant red; and though somewhat smaller than the stork, yet, from the great length of its neck and legs, it stands nearly five feet high. These birds are gregarious, and when they feed keep together, drawn up in line, resembling at a distance, from their height and color, a regiment of soldiers. Immense numbers are found along the rivers of South America.

The order of the *Natatores* includes such birds as possess comparatively short legs, webbed feet, and bodies adapted to swimming, as the duck, pelican, penguin, gull, and albatross.

One of the most important genus of the duck family is the eider-duck, so well known for the delicate down it affords. It is about twice the size of the common duck, and is found both in Europe and America, from the northern parallel of forty-five degrees to the highest latitude yet attained.

Within these regions they breed in immense numbers on the rocky shores of the mainland and of islands, the mother-bird making her nest of sea-weed and lining it with the soft down from her breast. A breeding-place visited by Dr. Kane in the Arctic Sea, and called by him Eider Island, was so thickly covered with nests that hardly a step could be taken without treading upon them.

The penguin, which sometimes weighs from sixty to seventy pounds, is mostly found in the high southern latitudes, where they are seen in countless numbers upon the snow-clad islands. Though scarcely able to walk, and possessing no power of flight, it nevertheless skims swiftly over the sea, and dives with great rapidity. One kind lives on the ice of the Antarctic Sea, and is said to weigh from sixty to seventy pounds.

Gulls are found in every latitude and sea. The stormy petrel, or Mother Cary's chicken, belongs to this family.

The albatross is the largest of all sea-birds, measuring from ten to twelve feet between the tips of its extended wings. It sweeps

Describe the Grallatores. Give an account of the Natatores.

southward over the Pacific nearly as far as the Antarctic Ocean, and northward to Behring Strait. From the strength of its wings, it flies with great ease, and rests at night upon the waves.

12. **Mammalia.**[1]—This class includes all those warm-blooded animals that bring forth their young alive and suckle them, and within its limits are found those creatures that are most useful and serviceable to man. It ranks highest in the animal kingdom, and comprises about 2000 living species, divided by Carpenter into twelve orders,—namely, *Marsupialia,*[2] *Monotremata,*[3] *Edentata,*[4] *Pachydermata,*[5] *Cheiroptera,*[6] *Insectivora,*[7] *Carnivora,*[8] *Rodentia,*[9] *Ruminantia,*[10] *Quadrumana,*[11] *Cetacea,*[12] and *Bimana.*[13]

13. *Marsupialia.*—This order embraces all such animals as the kangaroo, wombat, and opossum, which have a pouch formed by the fold of the skin of the abdomen, in which the females carry their young when partially formed.

The marsupials include one hundred and twenty-three known species, which are very irregularly distributed, for only twenty-one are found in the New World: all the rest belong to Australia and the adjacent isles. Not a single species is found in Europe, Africa, or the continent of Asia. The kangaroo is a native of Australia, and is one of the most noted of the marsupials. Its limbs are very disproportionate, the fore-legs being short and small and the hind-legs long and powerful; and on this account it is enabled to make most extraordinary leaps, passing over the ground at a rapid rate. Its young are but the rudiments of animals, and are immediately received into an outer bag or pouch beneath the belly of the mother, where they remain until they become fully developed. The well-known opossum is peculiar to America.

14. *Monotremata.*—This order is represented by only two animals, of a singular internal structure,—the duck-billed platypus and the porcupine ant-eater, both of which are peculiar to Australia. The former is about fourteen inches long, and has the body of an otter, but its head ends in a bill like that of a duck. The latter has spines like the hedgehog, and lives on ants.

15. *Edentata.*—This order contains only twenty-eight species, of which twenty are found in the New World, two in Asia, three in Africa, and three in Australia. Under this division are found such animals as the ant-eater, sloth, and armadillo.

The ant-eater is the largest of all the Edentata; and the great ant-eater, which is found in South America, measures from seven to eight feet in length. It is entirely destitute of teeth, and is characterized by an extremely elongated head and a long and narrow tongue, well adapted for collecting its peculiar food, which—as the name of the animal implies—consists of ants.

The sloth, which is so called from its slow motion, lives upon the leaves of trees, and is an extremely helpless creature upon the ground. It is found in the dense forests that extend from Mexico to Rio Janeiro, where "the deeper recesses of the woods," says Tschudi, "resound with its drawling, monotonous cry; and this emblem of misery, fixing itself upon an almost leafless bough, there remains defenceless, a ready prey to any assailant."

The armadillo, which abounds in South America, is covered with a shell formed of plates like a coat of mail. It is a harmless creature, and feeds on insects and vegetables, and is used by the natives for food. It runs with great speed, and, when near a precipice, eludes its pursuers by forming itself into a ball and rolling down the height in safety, protected by its shell. One species—the giant armadillo—is three feet in length.

16. *Rodentia.*—This order comprises no less than six hundred and four species, of which three hundred and twenty-five are found in the Old World, and two hundred and eighty-two in the New. It comprehends such animals as the squirrel, beaver, hare, rat, and prairie-dog.

The beaver, so noted for its sagacity and so much prized for its fur, is found in the rivers of Europe and Asia from the 36th to the 67th degree of north latitude, and in America from the confluence of the Ohio and Mississippi to the banks of the Mackenzie River. Beavers live in communities, and erect huts for themselves in ponds or running streams, constructing dams in the latter in order to obtain a sufficient depth of water. These dams are formed of trees, often five or six inches in diameter, which the beavers cut down with their teeth.

Rats are widely distributed, and follow man wherever he settles. When they become too numerous in any region, they migrate of their own accord. According to Pennant, the Kamtschatka rat sets out in spring in great multitudes, and travels for hundreds of miles, swimming the rivers that cross its path.

The prairie-dog is a species of marmot, and abounds in the great prairies of the West. They live in very large communities, their burrows—or villages, as they are called—being many square miles in extent.

17. *Insectivora.*—The term "insect-eating animals" may be applied to bats, and even some of the Quadrumana; but it is characteristic of those belonging to this order that they are peculiarly fitted by their organization for preying and living upon hard-bodied insects, such as beetles and locusts. This group, which contains sixty species, includes such animals as the hedgehog, shrew, and mole.

The European hedgehog, which is the best-known of this family, is about ten inches long. Its body is covered with sharp spines, and, when attacked, the animal rolls itself up into a ball, presenting nothing to its enemy but an array of pointed spines. Its principal food is insects.

The mole is about five or six inches long, and is furnished with short, palmated feet, which enable it to work its way under ground with great facility. It lives in places where the soil is loose and furnishes the greatest amount of worms and other insects, upon which it feeds. The fine and thick-set fur of this little animal is as soft as velvet.

18. *Cheiroptera.*—This order consists of the bat family, and includes two hundred and nineteen species. Most of these live upon insects; but some feed upon fruits and soft vegetable productions.

Bats fly only in the night, and during the winter in temperate climes live in a torpid state. In caves and dark chambers, such as occur in the Pyramids, they are found hanging in clusters from the sides and roofs, supported by the hooks with which the extremities

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[1] From the Latin word *mamma*, a "breast."
[2] From the Latin word *marsupium*, a "pouch."
[3] From the Greek words *monos*, "single," and *trema*, "opening."
[4] From the Latin word *edentatus*, "without teeth."
[5] From the Greek words *pachus*, "thick," and *derma*, "skin" (thick-skinned).
[6] From the Greek words *cheir*, "hand," and *pteron*, "wing" (wing-handed).
[7] From the Latin words *insectum*, "insect," and *voro*, to "devour."
[8] From the Latin words *carnis*, "flesh," and *voro*, to "devour" (flesh-eaters).
[9] From the Latin word *rodo*, to "gnaw."
[10] From the Latin word *rumino*, to "chew the cud."
[11] From the Latin words *quatuor*, "four," and *manus*, "hand" (four-handed).
[12] From the Latin word *cetus*, a "whale."
[13] From the Latin words *bis*, "twice," and *manus*, "hand" (two-handed).

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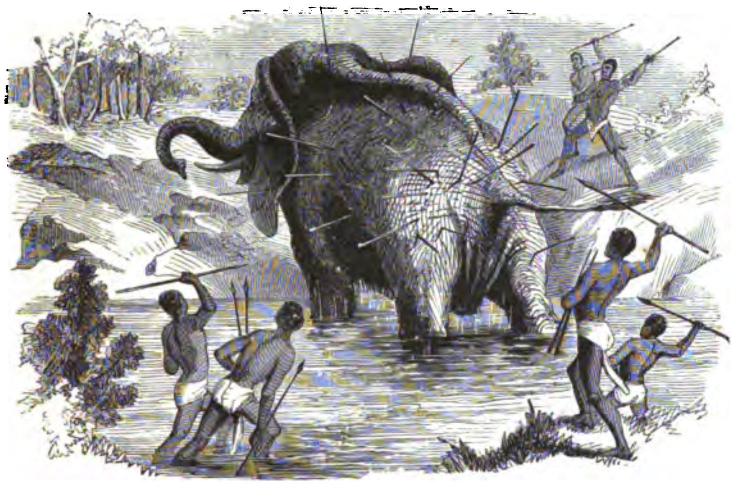
12. What are the peculiarities of the Mammalia? What is further said respecting this class of animals? Into how many orders are the Mammalia divided? Name these orders, and show how they are distinguished. 13. Describe the Marsupialia. 14. What of the Monotremata? 15, 16. State what is said respecting the Edentata and the Rodentia. 17, 18. Give an account of the Insectivora and the Cheiroptera.

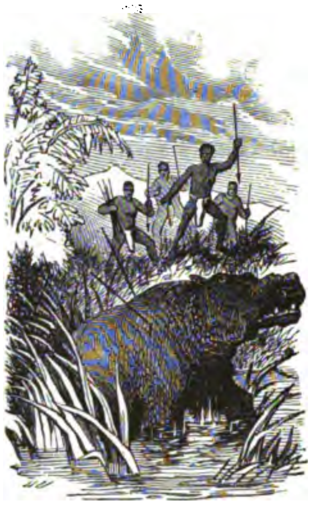
of their wings are furnished. Some of these animals, as the leaf-nosed bat and vampire, are remarkable for the expanse of their wings, which sometimes measures from two to three feet from tip to tip. This species suck the blood of domestic animals, and even attack man. Dr. Tschudi relates that he knew a bat to fasten upon the nose of a drunken Indian and suck so much blood that it could not fly away. The bat is found in nearly every part of the world; for it extends throughout the Western Continent, and ranges in the Eastern from the Arctic Ocean to Australia.

19. *Pachydermata.*—This order comprises, exclusive of the wild horse, thirty-nine species, besides those which are domesticated, such as the mule, ass, and hog. It includes the strongest and most gigantic quadrupeds, and various other animals, many of which are highly serviceable to man. The pachyderms are chiefly confined to the torrid zone, and delight in well-watered forests and jungles. The most noted families of this order are those of the elephant, rhinoceros, hippopotamus, horse, hog, and tapir.

The elephant, the mightiest of living quadrupeds, roams in herds amid the tropical forests of Asia and Africa. There are two species,—the Asiatic and African. The former ranges over a region which extends from Southern Sumatra through the peninsula of Malacca, embracing the southern provinces of China, all India, and Ceylon, and ascending the Himalayas, five thousand or six thousand feet, to the dense forests of Nepaul. The African species is smaller than the Asiatic, and is not so easily tamed. Its domain stretches from the northern limits of Cape Colony to the river Senegal in Western Africa, and northeasterly to Abyssinia as far as the 13th degree of north latitude. The elephant has been trained from the earliest times for warlike and domestic purposes, and is the most sagacious and intelligent of all animals. Its immense tusks consist of ivory, and form a valuable article of trade.


ELEPHANT ATTACKED BY NATIVES IN SUMATRA.

The rhinoceros, distinguished for its horn, is a powerful and savage animal, and a match for the elephant. It inhabits the thick forests of Asia and Africa, and its range in the latter country is the same as that of the elephant; but in Asia it extends farther north, into China, and to Java in the south, where the elephant is not found. There are seven species of the rhinoceros,—three Asiatic and four African. The Indian species has one horn, and the Asiatic two. The rhinoceros was well known to the ancients, and was introduced by the Romans in the games of the circus. It was first brought into England in 1684.


NATIVES HUNTING HIPPOPOTAMUS.

The hippopotamus, or river-horse, is a large, unwieldy animal, peculiar to Africa. It is there found in many of the rivers and lakes, where it feeds upon the herbage that grows in their beds, coming up every few minutes to the surface of the water in order to breathe. It is gregarious, and is a stupid, harmless animal, but when robbed of its young will attack and upset a boat, according to the experience of Dr. Livingstone.

The hog is the most widely diffused of all the pachyderms, and assumes the greatest variety of forms. The wild boar, which is the original stock of the common hog, ranges from the western shores of France to Japan and the Chinese Sea, and from the Sahara to the forests of Lithuania in Europe and Lake Baikal in Siberia.

The family of the horse is divided into three genera,—viz., the horse proper, the ass, and the zebra. The horse is found tamed in every part of the world, and, though doubtless originally wild, yet the time when it was first domesticated is so remote that its native abode is unknown. Vast herds of wild horses now roam over the highlands of Tartary and the plains and pampas of the Western Continent; but these are regarded as the descendants of domesticated animals. The wild horses of America have sprung from tame horses turned loose by the Spaniards; and the herds of Tartary are supposed to have originated in a similar way. This noble and intelligent animal has from the earliest antiquity been eminently serviceable to man, and is highly prized for its strength, speed, and beauty.

The wild ass is found in herds of countless numbers throughout Central Asia and Mongolia, whence they migrate southward on the approach of winter. The common ass, which appears to have been tamed at an earlier period than the horse, is supposed to be descended from the wild ass of Tartary, which is remarkable for its speed and fiery disposition.

The zebra belongs only to Africa, and ranges northerly from Cape Colony to Congo, Guinea, and Abyssinia. One of this species,—the quagga,—though bold and fierce on its native plains, has been occasionally domesticated.

The tapir belongs almost exclusively to South America. Only a few years ago it was discovered in Sumatra, Malacca, and some of the adjacent isles. The American tapir is a large animal, resembling the hog in form, and when full-grown is six feet long and three and a half high. During the day they repose in the deep recesses of the forest, whence they issue at night to prey upon the products of the plantations.

20. *Carnivora.*—This order, which includes beasts of the most bold, cruel, and ferocious disposition, is represented in every part of the world. The Carnivora possess a structure for tearing, devouring, and digesting the flesh of the weaker animals upon which they prey, and are found in the greatest numbers where the latter are most numerous. They abound in the torrid zone; but their distribution throughout different countries is very irregular.

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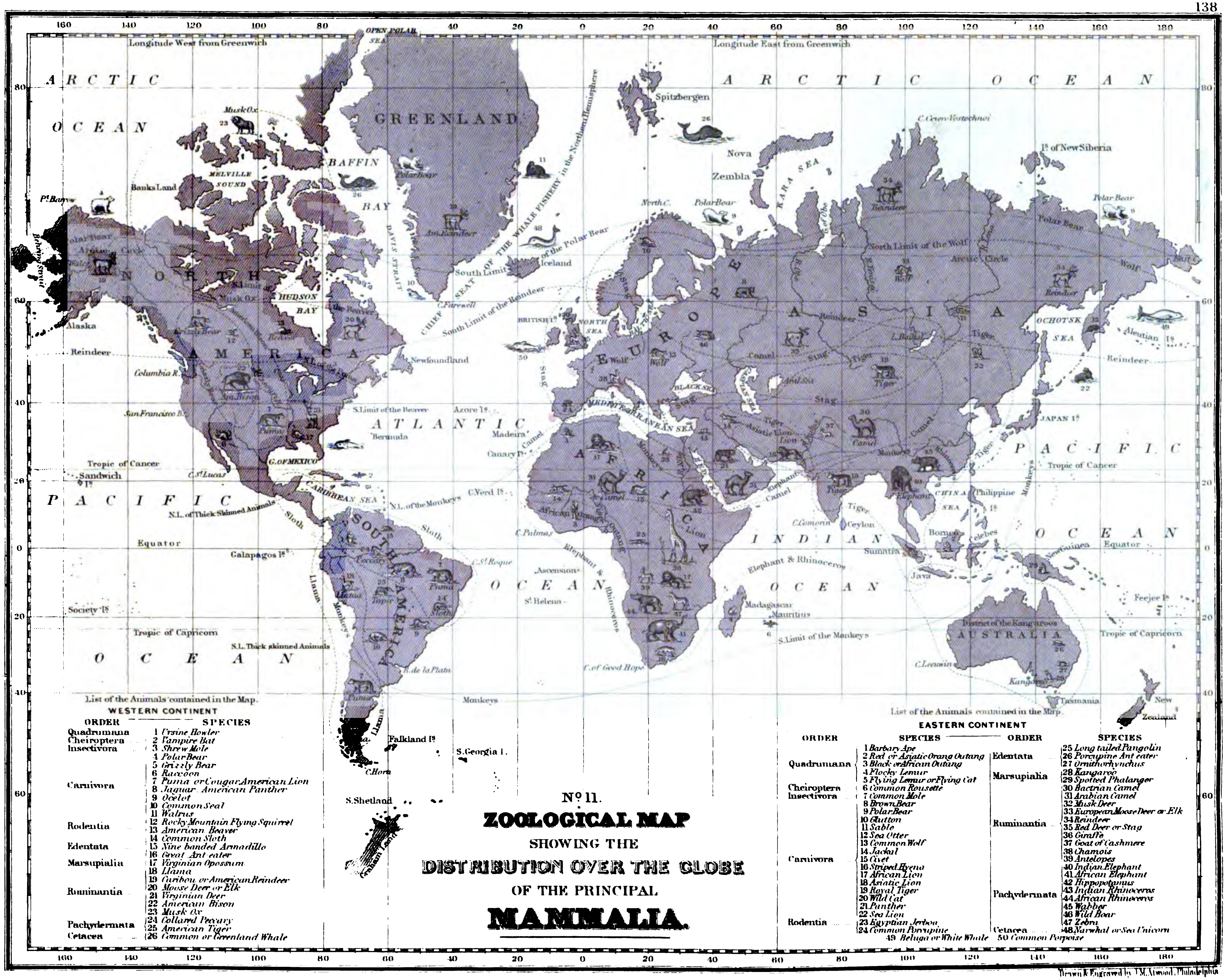
19. What is said of the Pachydermata? Where are they chiefly found? What is said of their size? Describe those which are mentioned. 20. What is said respecting the nature and distribution of the Carnivora, and the number of their species?



List of the Animals contained in the Map.

WESTERN CONTINENT

ORDER	SPECIES
Quadrumana	1 *Ursine Howler*
Cheiroptera	2 *Vampire Bat*
Insectivora	3 *Shrew Mole*
Carnivora	4 *Polar Bear* 5 *Grizzly Bear* 6 *Racoon* 7 *Puma or Cougar, American Lion* 8 *Jaguar. American Panther* 9 *Ocelot* 10 *Common Seal* 11 *Walrus*
Rodentia	12 *Rocky Mountain Flying Squirrel* 13 *American Beaver*
Edentata	14 *Common Sloth* 15 *Nine banded Armadillo* 16 *Great Ant eater*
Marsupialia	17 *Virginian Opossum*
Ruminantia	18 *Llama* 19 *Caribou or American Reindeer* 20 *Moose Deer or Elk* 21 *Virginian Deer* 22 *American Bison* 23 *Musk Ox*
Pachydermata	24 *Collared Peccary* 25 *American Tiger*
Cetacea	26 *Common or Greenland Whale*

List of the Animals contained in the Map.

EASTERN CONTINENT

ORDER	SPECIES	ORDER	SPECIES
Quadrumana	1 *Barbary Ape* 2 *Red or Asiatic Orang Outang* 3 *Black or African Outang* 4 *Flocky Lemur* 5 *Flying Lemur or Flying Cat*	Edentata	25 *Long tailed Pangolin* 26 *Porcupine Ant eater* 27 *Ornithorhynchus*
Cheiroptera	6 *Common Rousette*	Marsupialia	28 *Kangaroo* 29 *Spotted Phalanger*
Insectivora	7 *Common Mole*	Ruminantia	30 *Bactrian Camel* 31 *Arabian Camel* 32 *Musk Deer* 33 *European Moose Deer or Elk* 34 *Reindeer* 35 *Red Deer or Stag* 36 *Giraffe* 37 *Goat of Cashmere* 38 *Chamois* 39 *Antelopes*
Carnivora	8 *Brown Bear* 9 *Polar Bear* 10 *Glutton* 11 *Sable* 12 *Sea Otter* 13 *Common Wolf* 14 *Jackal* 15 *Civet* 16 *Striped Hyena* 17 *African Lion* 18 *Asiatic Lion* 19 *Royal Tiger* 20 *Wild Cat* 21 *Panther* 22 *Sea Lion*	Pachydermata	40 *Indian Elephant* 41 *African Elephant* 42 *Hippopotamus* 43 *Indian Rhinoceros* 44 *African Rhinoceros* 45 *Wabber* 46 *Wild Boar* 47 *Zebra*
Rodentia	23 *Egyptian Jerboa* 24 *Common Porcupine*	Cetacea	48 *Narwhal or Sea Unicorn* 49 *Beluga or White Whale* 50 *Common Porpoise*

Nº 11.

ZOOLOGICAL MAP

SHOWING THE

DISTRIBUTION OVER THE GLOBE

OF THE PRINCIPAL

MAMMALIA.

Drawn & Engraved by J.M. Atwood, Philadelphia

The Carnivora, not including the extensive group of the bats, includes two hundred and twenty-nine species, comprised under two families,—namely, the *Plantigrades*[1] and *Digitigrades*.[2]

Of the Plantigrades, the bear is the most worthy of notice. The brown bear, which is still found amid the Alps and Pyrenees, ranges over the northern regions of the Eastern Continent from Norway to Kamtschatka and Japan. In the Western Hemisphere, the black bear roams over the vast regions lying north of the northern parallel of thirty degrees.

GRIZZLY BEAR.

The grizzly bear, the most formidable of all, and terrible for its strength and ferocity, is found only within the Rocky Mountains and their vicinity.

The polar bear, fierce and dangerous, dwells in the Arctic climes, and ranges no farther south than about the 55th degree of north latitude. It is a bold swimmer, and preys upon seals and the carcasses of whales.

To this family also belong the wolverine, raccoon, and badger.

The Digitigrades, which are diffused throughout the globe, contain numerous genera, the most important of which are those of the *felines*[3] and *canines*[4]. The former, which range over all the world except Australia and Oceanica, include the most bold, powerful, and ferocious beasts of prey, such as the lion, tiger, puma, jaguar, leopard, and panther. The lion roams over nearly the whole of Africa, but in Asia is confined to particular districts in Arabia and Persia, to the country bordering the Euphrates, and to certain parts of India.

The lion possesses immense strength, and is said to be able to seize and carry off a heifer or antelope; yet it is questionable if he dares singly to attack the buffalo. From his boldness and supposed magnanimity, he has been termed the "king of beasts;" but, according to Dr. Livingstone, he has no claim to this distinction.

More active than the lion, and its equal and perhaps its superior in strength, is the royal tiger, which is found only in Asia, and chiefly within the torrid zone. Stealthy in its approach and cruel in its disposition, it is the terror of the natives of India. The puma—called the American lion, but inferior to the true lion in strength and size—is found from Patagonia to the Great Northern Lakes. It is bold and ferocious, and in Peru fearlessly attacks mules and horses. The jaguar lives chiefly in Brazil and Paraguay, and almost rivals the tiger in strength and ferocity. It has been known to kill a horse, drag it nearly two hundred feet to a river, swim across the stream with its victim, and then carry it into the adjoining forest. The leopard and panther are natives of Africa and the southern parts of Asia, and are beautiful and graceful animals.

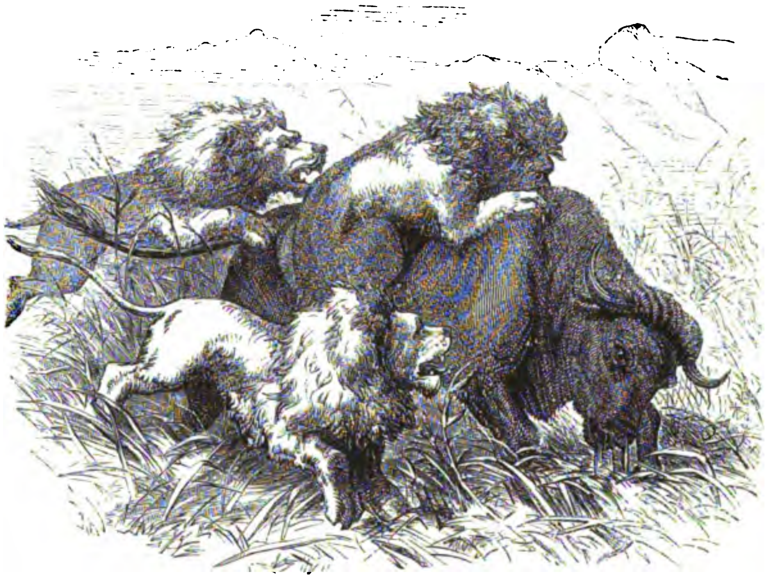
To this group belongs also the wild-cat, which in Europe is the only representative of the felines in their wild state.

The principal representatives of the canines are the dog, wolf, jackal, and fox. The dog follows man in all his migrations, not as a parasite, but as a faithful and attached companion, his affections being of a personal nature and existing even under ill treatment. In India a species of dog exists in a wild state, called the dhole, and in Australia the dingo is found, which hunts in packs; but it is believed that these animals are the descendants of domesticated races.

The wolf is found in North America, throughout nearly all Europe, and in Northern Asia. It is a doubtful question with naturalists whether the wolf is not the original stock of the dog.

The fox occurs in America, Europe, and Northern Asia, and is represented by several varieties,—as the red fox of North America, which is regarded as identical with the common fox of Europe; the black fox, distinguished for its rich black fur; and the Arctic fox, whose hair in winter is of a pure white color, and covers a thick, soft fur that encases even the soles of the feet of the animal.

To the Carnivora also belong the savage hyena, and the civet-cat, noted for its perfume. Here are likewise found the weasels, from some of which—as the marten, sable, and ermine—the most costly



LIONS ATTACKING A BUFFALO.

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[1], [2] From the Latin words *planta*, the "sole of the foot," and *gradior*, to "walk" (Carnivora that walk on the soles of their feet), and *digitus*, a "toe," and *gradior*, to "walk" (Carnivora that walk on their toes).

[3], [4] From the Latin words *felis*, a "cat," and *canis*, a "dog."

What two families does it comprise? Why are they so called? What is said in regard to the plantigrades? Give an account of the diffusion of the digitigrades, and mention the most important genera. What is said of the felines? Give an account of the lion, tiger, puma, jaguar, panther, leopard, and wild-cat. Describe the canines, and the several animals which are mentioned as belonging to this group. What other animals are embraced in this order?

and valuable furs are obtained. The sable inhabits the polar climes, and is hunted in the depth of winter, amid the most desolate regions.

In this order are also ranked the otters, the most remarkable of which is the sea-otter, which is found off the northwestern coast of America and is valued for its beautiful dark fur.

WALRUS AND SEALS.

21. *Marine Carnivora.*—Under this division are included the seal and the walrus, which have the peculiarities of the true Carnivora. Seals are found in the temperate and frigid regions of the globe, and are much prized for their skins, fur, and oil. The elephant-seal is the largest known species, and measures from twenty to thirty feet in length. The walrus in its form and habits resembles the seal, and is armed with solid tusks from eighteen to twenty inches in length. It is a bold animal, and with its formidable weapons defends itself even against the attack of the polar bear. The seal and walrus are invaluable to the inhabitants of the Arctic regions, as they constitute not only their staple food, but contribute in a variety of ways to their necessities and comfort, furnishing fuel, light, thread, clothing, and covering for their boats and tents.

22. *Ruminantia.*—This order consists of animals that live upon vegetables, and, according to Johnston, embraces 180 species. The most important families are those of the giraffe, antelope, goat, sheep, ox, camel, llama, and musk-deer.

Of all animals, the Ruminantia are most useful to man. Some serve him as beasts of burden and of draught, and others furnish him with food and clothing, and with many articles that conduce to his comfort. They are distributed over the globe from the equator to within the Arctic regions, and are essentially connected with the welfare and diffusion of the human family. From the earliest period, some of them have been domesticated; and, with the exception of a few of the more desolate regions of the Arctic climes and a small number of the Pacific isles, there is hardly a spot on the globe where the ox, sheep, and goat are not found. A few kinds, as the llama, camel, and reindeer, seem to be especially serviceable only in the regions where they are found.

The deer, distinguished for its gracefulness and beauty, is distributed over nearly the whole globe. Among the most noted of this family are the fallow-deer, the reindeer, and the elk. The reindeer is found in the north of Europe, and is confined to the polar climes. To the inhabitants of these regions it is invaluable, as it furnishes them with flesh, milk, and the means of transportation, carrying them rapidly on sledges across the snowy wastes. The elk, or moose-deer, which has its home in the coldest parts of the Northern Hemisphere, was formerly somewhat numerous in Europe, but is now chiefly found on the Western Continent in the vicinity of the Great Northern Lakes and amid the forests on the St. Lawrence. It is as large as a horse; and its horns, or antlers, when fully formed, weigh from fifty to sixty pounds.

The giraffe, which is found only in Africa, is a graceful and delicately-formed animal, and so tall that it sometimes attains the height of eighteen feet. It is hunted for the sake of its beautiful skin, and, though a timid creature, defends itself vigorously when brought to bay, by kicking with great rapidity.

The fleet and elegant antelope is found in the warmer zones, and chiefly inhabits Africa. A few species exist in Asia, a still smaller number in America, and only two in Europe. Among the most remarkable of the antelopes are the springbok, gazelle, and chamois.

GIRAFFES.

The springbok is a native of South Africa, where it covers the plains in vast numbers, from 25,000 to 30,000 animals being sometimes seen in a single herd.

The gazelle, celebrated for its rare beauty and exquisite form, is found in Arabia and Syria, congregated in large herds. In speed it outstrips the greyhound, and is hunted by the aid of falcons; but, though wild and timid, it is easily tamed.

The chamois dwells amid the snowy heights of the Alps, Pyrenees, and Carpathian Mountains, and among the Caucasian and Taurian ranges.

The ox family comprises the largest animals among the Ruminants, and, either in a wild or domesticated state, is diffused over nearly the entire globe. The ox has been so long domesticated that its origin is unknown; but Central Asia is generally regarded as the home of the parent stock. The principal animals of this family are the buffalo, bison, urus, yak, and musk-ox.

The buffalo is a powerful and ferocious animal in its wild state, boldly meeting the tiger, and often vanquishing him in the conflict. In defence of its young a buffalo-cow will attack the lion, and sometimes kill him.

The American bison,—commonly termed the buffalo,—though formidable in appearance, is dangerous only when wounded and brought to bay. It formerly dwelt in the eastern portions of the United States, but is found now only in the remote regions of the West, ranging, in immense herds, from about the 64th degree of north latitude to New Mexico and California.

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21. What is said respecting marine Carnivora? 22. What is said respecting the nature, number, families, usefulness, and diffusion of the Ruminantia? State what is said of the family of the deer, giraffe, and antelope. Describe the ox family, and the chief animals belonging to it.

The urus, aurochs, or European bison, is an exceedingly ferocious and untamable beast. It is described by Cæsar and other ancient authors under the name of the urus, and in those remote times roamed through the unbroken forests of Central Europe. It is now found only in the dense woods of Lithuania.

The yak, already alluded to, is a very hardy animal, and, according to Lieutenant Wood, is as serviceable to the inhabitants of Thibet and Pamir as the reindeer is to the Laplander. Its home, even in the winter, is amid the ice and snows of the Himalayas; and if the snow is too deep for it to crop the herbage, the animal rolls himself down some declivity, laying bare the dried grass, and then eats his way up in the path he has made.

The musk-ox, scarcely equal in size to the smallest Scottish cattle, inhabits the coldest region of North America, and is distinguished for a strong, musky odor, whence it derives its name.

The goat is found in certain portions of Europe and Africa, but abounds most on the Asiatic Continent. The original stock of the common goat is unknown, but it is probably the same with that of the half-tamed breeds that inhabit Asia. The Syrian goat is much prized for its milk; and its hair from a very early period has been employed in the manufacture of cloths. From the fine and silky hair of the Cashmere goat are fabricated the beautiful and costly Cashmere shawls.

The Caucasian ibex, which belongs to this group, is a bold and powerful animal, and, when driven to bay in its native heights, turns on its pursuer and hurls him headlong from the cliffs.

The sheep appears, by the earliest records, to have been the first animal domesticated by man, and its native abode is supposed to be in Western Asia. In the inaccessible mountains of Europe, Asia, Africa, and America, they herd together in a wild state, but are most numerous in Asia. This valuable animal is greatly affected by external circumstances, and especially by climate, producing a thick and silky fleece in the temperate climes, which changes in a year or two to crisp brownish hair if the animal is transported to a tropical clime.

The Egyptian and Syrian sheep have enormous tails, which sometimes weigh seventy or eighty pounds.

The family of the camel consists of two genera,—the Arabian, or one-humped camel, and the Bactrian, or two-humped; both of which are completely domesticated.

The Arabian camel, called "the ship of the desert," is distributed over Southwestern Asia, the south of Tartary, and part of India. It is peculiarly fitted by its structure for traversing the arid wastes of its native regions, since it possesses a supplementary stomach as a reservoir for water, and its fatty hump, when the animal is without sustenance, partially supplies the place of food.

CAMELS.

The dromedary, which is a species of the Arabian camel, is distinguished for its speed. Burckhardt relates that one of these animals carried its rider one hundred and fifteen miles in eleven hours, including twenty minutes employed in crossing and recrossing the Nile.

The Bactrian camel, which is found in Central Asia and in the countries bordering on the Caucasian Mountains, is a strong animal, well adapted to traversing rugged ground. A pair of Bactrian camels will draw a load of from three thousand to four thousand pounds fifty miles, on a good road, without eating, drinking, or halting.

So highly prized is the camel by the Arab that he believes this animal and the date-tree to have been made from the same clay as Adam, and that he will meet them in paradise.

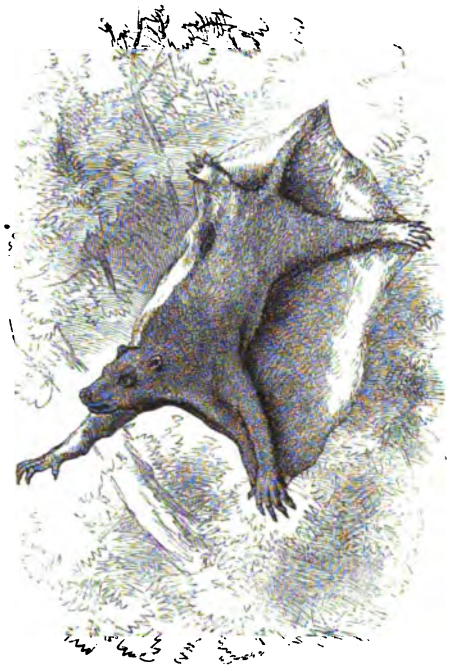
The llama resembles the camel, but is much smaller, and possesses neither a hump nor an additional stomach. It belongs exclusively to South America, and is restricted to the lofty ranges of the Western Andes, which extend from Venezuela to Patagonia. At the time of the conquest of Peru the llama was the only beast of burden in South America, and was kept in immense flocks, both for the purposes of traffic and for food.

THE LLAMA.

This animal is more sure-footed than the mule, and llamas are now employed, as they were formerly, in transporting the products of the silver-mines across the rugged ranges of the Andes. The guanaco, alpaca, and vicuña belong to this family.

The musk-deer, which is a native of Asia, is prized on account of its secreting the odoriferous substance called musk, which is much used as a perfume.

23. *Quadrumana.*—The Quadrumana consist of the tribe of monkeys, comprising, with the lemurs, one hundred and seventy species, of which ninety-one belong to the Western Continent and seventy-nine to the Eastern. The most noted divisions of this order are apes, monkeys, and baboons.


FLYING LEMUR.

The most remarkable of all the apes is the gorilla, which lives in Western Africa. It is from six to seven feet high, is terrible for its strength and ferocity, and roams in the depths of the forest without a rival.

The orang-outangs, which also belong to the apes, are as tall as a man, and have sufficient instinct to construct a kind of hut for themselves by twining together the branches of the trees in which they reside.

The chimpanzee is the most gentle of all the apes.

The slow monkey, which abounds in many parts of India, is regarded as a divinity by the natives, splendid temples being erected to its honor, and hospitals built for its reception when sick or wounded.

Of all the baboons the largest and most ferocious is the mandrill, which, when erect, is

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Describe the families of the goat, sheep, and camel, and the various animals that respectively belong to them. Give an account of the llama. What other animals are classed in this family? What is said of the musk-deer? 23. Describe the Quadrumana, and the several animals of this order which are mentioned.

nearly as tall as a man. It inhabits Western Africa, and issues from the forests in large numbers, plundering the cultivated fields with impunity. When excited, it is extremely ferocious, attacking and killing small animals, and is more than a match for an unarmed man.

The lemurs are harmless and gentle animals, and are found only in the island of Madagascar. Allied to them is the Galeopithecus, or flying lemur, which is distinguished for an extension of the skin between the fore and hind limbs on either side, including the tail, so as to form a kind of parachute, by which it is enabled to take long flying leaps from tree to tree.

24. *Cetacea.*—The animals of this order surpass all others in bulk, and are represented by three families,—namely, the whalebone whale, the spermaceti whale, and the dolphin.

The whalebone whale was formerly caught in the Mediterranean and the Bay of Biscay; but its range is now more restricted, and it is chiefly found in the Northern Ocean and the North Pacific, though it has, however, been met with in the Antarctic climes. It comprises two genera,—the Greenland whale and the rorqual. The first is from sixty to even eighty feet long, and is extremely valuable on account of the oil which it yields, and also for its whalebone. The rorqual, which attains a length at times of one hundred feet, furnishes but little oil.

The sperm whale is a huge animal, sometimes seventy-five feet long, its enormous head being equal in length to the rest of its body, and exceeding it in bulk. These immense creatures swim in herds or schools, numbered often by hundreds and by thousands; for they are seen at times, from the masthead of a whaleship, breaking the surface of the ocean as far as the eye can reach. Bold and daring, the sperm whale fights fearlessly when attacked by the whalers, and no sooner is it wounded than its companions rush to its aid. In the desperate conflicts that ensue, it often staves in the strong whaleboats with a single blow of its tail, or crushes them to pieces in its powerful jaws. It ranges over nearly the entire ocean, from the 60th degree of north latitude to the 60th or 70th degree of south latitude, and, notwithstanding the dangers of the pursuit, is eagerly sought for the oil and spermaceti it furnishes, which latter substance is contained in a receptacle in its enormous head.

The various species of the dolphin range throughout every sea, from the equator to the poles; and among the most important members of this family are the narwhal, beluga or white whale, porpoise, and dolphin. The narwhal—or sea-unicorn, as it is termed—has a strong tooth projecting from its upper jaw to the length of from six to ten feet. It is a large, powerful animal, and swims with amazing speed: when attacked, it defends itself boldly, and has been known to drive its tusk deep into the oaken sides of a ship. The home of the narwhal is the polar seas as far as the parallel of 70 or 80 degrees.

The beluga, or white whale, receives the latter name from the whiteness of its skin. This animal dwells in the northern seas, and abounds in Hudson Bay and Davis Strait.

The porpoise, which is a strong and voracious animal, is seen in the Atlantic in vast schools, sporting and tumbling amid the waves.

The dolphin differs from the porpoise in form principally in having its snout prolonged into a kind of beak. It is an active animal, and is frequently seen swimming around vessels when under full sail.

Allied to the Cetacea are the Manatidæ, or Dugong family, which differ from the former in living on herbs instead of fish. The dugong, which has its home in the seas of the Indian Archipelago, is an animal from eighteen to twenty feet in length. It frequents shoal waters and the mouths of rivers, and is hunted for its flesh, which is tender and palatable. It feeds on sea-weed, and is so tame as to suffer itself to be handled. The manatus, a similar animal, from six to seven feet in length, is chiefly found in the great rivers of Northern and Northeastern South America. It also lives on the coasts of Mexico and of the West Indian Isles, and in some of the tropical rivers in Western Africa. The steller, which belongs to this family, and dwells in the North Pacific, is an immense animal, measuring when full-grown twenty-five feet in length and eighteen in circumference.

In 1741, the shipwrecked party of Behring were supported for two months principally by the flesh of a steller found upon one of the islands in Behring Strait.

25. *Bimana.*—Man constitutes this order; and his distribution will form the subject of the next chapter.

26. **Mutual Dependence of Plants and Animals.**—In the mechanism of the world nothing is isolated, but the various parts are intimately connected with each other. All vitality is dependent upon the earth, the water, the air, and the sunbeam; and a mutual relation exists between vegetable and animal life. A healthy plant increases by the absorption of carbon, while it largely gives forth oxygen into the atmosphere. The animal needs the oxygen of the air for respiration, and breathes out again a portion of the oxygen charged with carbon. Thus these two great kingdoms minister to each other, and preserve that due balance in the constitution of the atmosphere which renders it healthful and a common nourisher to every form of life that is found upon the globe,—an arrangement which exhibits in a wondrous manner the unity of plan pursued by the Creator.

27. **Subserviency of Animals to Man.**—Dominion was given to man over every living thing that moves upon the earth; and no diligent student of zoology can fail to see how fully this sovereignty exists, and how numerous are the special adaptations of the nature of animals to the wants of the human race. The useful animals, like the useful plants, are most widely diffused, and, under one type or other, attend upon man wherever he fixes his abode; while the fiercest Carnivora, as the lion, tiger, and jaguar, are confined in their range, and have their homes within the torrid climes of the globe.

The whole animal world is taxed for his necessities and pleasures. The sheep, in the temperate regions, furnishes its fleece for man's warmer clothing; the furs of the Arctic climes protect him from the winter's cold; and from the shroud of the silkworm are woven the richest and most beautiful fabrics. On the land, the various tribes both of wild and tame animals, as well birds as beasts, yield a rich variety of diet for his sustenance; and the ocean also presents its vast stores of food. Beneath his yoke the stronger animals till the soil, bear his burdens, and transport him with speed from place to place. In various ways they likewise contribute to his comforts, tastes, and pleasures: the monsters of the deep yield their oil to light his dwelling, the elephant falls to furnish him with ivory, the shells of the sea give up their pearls, and birds offer their tribute of bright and flowing plumage, or charm his ear with their varied song.

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24. What is said of the Cetacea? Describe the several families which belong to this order. 26. What is said respecting the mutual dependence of plants and animals? 27. What is stated in regard to the subserviency of animals to man?

CHAPTER III.

ETHNOLOGY.

1. **Ethnology** is that science which treats of the races of mankind, and of their diffusion over the globe.

2. **Man.—His Characteristics.**—Man, the connecting link between animal and spiritual existences, has been invested by his Creator with the sovereignty of the world, and is eminently fitted, both by his physical organization and his mental and moral endowments, for the high station which he holds. Unlike other animals, he possesses a flexibility of constitution, and a control over material agencies, which enable him to dwell in every climate that does not absolutely preclude organic existence.

Thus, the naked negro lives chiefly upon a vegetable diet, and basks beneath the rays of a tropical sun; while the fur-clad Esquimaux, gorged with the heat-producing fat of the walrus, finds his snow-built hut a genial home when the temperature of his dwelling rises to the freezing point. The European, accustomed to a temperate clime, explores with impunity as well the burning deserts of Africa as the ever-frozen wastes of Greenland.

The amount of heat generated in the human system is in proportion to the quantity of carbon contained in the food consumed. Animal food is much richer in carbon than vegetable products; and it is upon this that the natives of the extreme high latitudes depend to keep up their strength and to supply the loss of vital heat. They live entirely upon flesh and fish; and the amount of fat and blubber which a person will daily consume is absolutely enormous. In the temperate climes, where bread-grains abound, a mixed diet is adopted; while in the tropical regions the inhabitants subsist mostly upon rice, vegetables, and fruits. If man had been capable of living only on vegetable food, he could never have obtained a permanent residence beyond the limit of the bread-grains.

The human system not only adapts itself to differences of diet and temperature, but also to the varying pressure of the atmosphere and to changes in moisture; for mankind dwell alike on the sea-coast, and on the very verge of the snow-line amid the lofty mountains of the globe, where the air that is inhaled is dry and attenuated.

Man asserts his dominion over the globe far more by his intellectual than by his physical power; for, seeing the adaptation of means to ends, he makes not only the animal and vegetable kingdoms subservient to his wants and pleasures, but also guides the mighty agencies of the globe and causes them to work at his bidding. Highest of all is his spiritual nature, by which he is enabled to look forward to an immortal life, and to rise higher and higher in the scale of humanity as he follows the revealed will of his Creator. Thus gifted, he has so widely explored his domains that but few regions have been found without native inhabitants. The chief of these, according to Milner, are Spitzbergen, Nova Zembla, Iceland, Madeira, St. Helena, the Falkland Islands, Kerguelen Land, the Antarctic regions, and the African Desert (excluding its oases).

3. Notwithstanding man adapts himself to his varied external conditions, it is doubtless true that he has also been modified by them, both in regard to his physical and intellectual nature; though the extent of their influences cannot be rigorously defined. The quality and quantity of their food, the heat and moisture of their climate, the nature of the soil on which they dwell, the low or lofty position of their abode, all have their due effects upon a race, and may, in the lapse of time, produce marked changes even in their physical structure.

The Magyars are a case in point. Nearly a thousand years ago they were driven from the north of Asia, their native region, and took up their abode in Hungary, exchanging a rigorous for a genial climate, and their nomadic habits for a settled mode of life. Within the interval of ten centuries the race has become so modified that it is essentially European, and the shape of the skull has changed from a pyramidal to an oval form.

A hot climate and a bounteous soil, where but little labor is needed to procure the necessaries of life, tend to enervate the body and mind; but a temperate clime, where both the hand and the head must be constantly at work, is favorable at once to physical, intellectual, and moral development. An extremely cold climate checks the growth of the body; and the inhabitants of such regions are found to be diminutive in stature.

The condition of man in respect to civilization influences also his appearance. The most savage tribes are said to be the ugliest; for their uncontrolled passions, low desires, anxieties, and sufferings, mar and deform the countenance; while amid nations distinguished for a high intellectual culture and the exalting influences of Christianity, the face, which is the index of the internal feelings and emotions, possesses a refinement of expression unknown to the savage races.

4. **Number and Diversities of the Human Race.**—The population of the globe is estimated by some authorities at 900,000,000, while others place it as high as 1,000,000,000, and even 1,300,000,000.

This vast number of human beings is divided into nations, races, and kindreds, widely differing from each other, not only in external appearance, but also in their moral, intellectual, and social condition, —ranging through numerous grades, from tribes of degraded savages and ferocious cannibals, to the most refined nations of the West. The chief diversities observed among mankind are those which relate to *physical appearance and structure*, *mode of life*, *language*, and *religion*.

5. **Physical Appearance and Structure.**—The various divisions of the human race differ from one another in height, in the color of the skin, hair, and eyes, in the form of the skull, and the proportion of the limbs. In respect to stature, the Esquimaux, Fuegians, and Peruvians are diminutive, while the Caribs, Patagonians, the natives of the Society Isles, and the Kaffirs, are tall and stately. The average height of the English is five feet seven and a half inches, that of the Patagonians six feet; while among the Bushmen the ordinary height of the men is four and a half feet, and that of the women four feet.

The difference in the color of the skin is one of the most marked distinctions of mankind; for we find their complexion ranging from a deep black, through shades of brown, red, yellow, and olive, to a clear white, tinged on the cheek with red. The true skin is, however, similar in texture in all nations,—the hue being caused by the presence of some coloring matter in the epidermis, or scarf-skin. The color of the skin appears, in general, to correspond with that of the eyes and hair; for persons with fair complexions have usually light hair and light blue or gray eyes, while those of dark complexion have for the most part dark hair and eyes. Apart from color, the hair of different races has other peculiarities: thus, the hair of the negro is fine, wiry,

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What is the subject of Chapter III.? 1. Define Ethnology. 2. What is said of man in respect to his physical organization and endowments? What relations exist between food and climate? What other adaptations are mentioned? What is said of the intellectual power of man? What of his spiritual nature? Is man found in almost every region of the globe? 3. How is man affected by his external conditions? 4. What is the population of the world? What is its condition? What are the chief diversities that occur among mankind? 5. State what is said respecting physical appearance and structure.

and crisp, having the appearance of wool; that of the Mongolian is strong and straight; that of the European is soft, long, and flowing.

The hue of the skin is not of a permanent character, but is regarded as due to local influences; for races exist which, though intimately related in other respects, vary nevertheless in this particular. Thus, in India, the Rohillas are a fair race, while the Bengalese are dark, and the Mahrattas yellow. The tribes bordering on the African desert are nearly as black as the darkest negroes; but the Kabyles of Tunis are brown, and a race has been found on the table-lands of Africa having a fair and ruddy complexion, with yellow hair.

In regard to structure, the most important difference observed among the human family is in the form of the skull. According to Dr. Pritchard, there are three varieties:—the *oval*, which characterizes the Caucasian race, and is seen in its perfection among the Greeks; the *narrow* or *elongated form*, which is beheld in the African, and marks the negro of the Guinea Coast; and the *pyramidal*, which belongs to the Mongolian type, and is most observable in the Esquimaux. The Negro race is distinguished by the broad, flat foot, projecting heel, and curved shin; while the length of the fore-arm in proportion to that of the upper arm and the height of the body, is greater than in other races.

6. **Modes of Life.**—Man, lost to almost every ennobling influence, sunk in ignorance and vice, the slave of debasing superstition, and obliged to exert all his ingenuity to escape his foes and to obtain a precarious subsistence, descends almost to a level with the brute. His home, if home he has, is a narrow and filthy abode, his food is often of the most disgusting kind, and his habits are brutal and revolting. But in proportion as his higher nature gains the mastery over the lower, he rises in the scale of being, and his social condition is improved, until at length, under the highest civilization, he lives surrounded with every thing that can contribute to his physical comfort, refine his intellect, and exalt his soul. To appreciate this truth, we have simply to compare the social and moral condition of the debased tribes of South Africa and of the fierce savages of Polynesia with those of the Christian nations of Europe and America.

Mankind are divided into five classes, in regard to their social condition, which are characterized as the Savage, Barbarous, Half-Civilized, Civilized, and Enlightened states.

THE SAVAGE STATE.

In the *savage* state, man is lawless, ignorant, vicious, brutal, superstitious, and ferocious, and delights in war and bloodshed. He supports himself by hunting and fishing, and by the spontaneous productions of the earth. Vermin and insects sometimes constitute his food, and he even feeds upon human flesh. His dwelling is of the rudest character, consisting of a wigwam or hut, and sometimes is nothing more than a cave or hole in the rocks. To this class belong such races as the untamed Indians of America, the natives of Australia, and the fierce inhabitants of some of the Polynesian isles, where human flesh is suspended in joints on the trees around the abodes of their chiefs, like meat on the hooks of a butcher's stall.

THE BARBAROUS STATE

The nations that live in the *barbarous* state are bold and predatory, and nomadic in their habits, roaming from place to place with their flocks and herds, whose flesh and milk constitute their chief support. They till the land to some extent, live in tents or simply-constructed houses, and their government is patriarchal, being vested in the chief of a clan or tribe. In this class are found the Tartar tribes of Asia, and the rapacious Arabs of the desert.

THE HALF-CIVILIZED STATE.

In the *half-civilized* state, man adopts a settled mode of life, and congregates in towns and cities. He derives his support principally from the tillage of the soil, and practises with success useful and ornamental arts, but scarcely at all employs the great agencies of nature to assist him in his labors. Literature is not unknown; and science is cultivated to some extent, but does not rise to the deduction of grand principles and truths. In this division are included the ingenious Japanese, the Chinese, Persians, and Turks.

The *civilized* state is marked by a higher degree of progress, and is that condition of society where the well-being of the community and the prosperity of the individual are together advanced. Agriculture is systematically and skilfully pursued, the practical applications of science are numerous, diversified, and ingenious, and trade and commerce flourish. The nations embraced in this class are for the most part distinguished for their just laws, intellectual culture, advanced morality, and the general acknowledgment of the claims of Christianity. Russia and Spain may be ranked in this division.

The *enlightened* state is that where all the essentials of civilization are best developed. Among the nations which hold this high position are England, France, and our own country.

7. **Language.**—Language distinguishes man from all other animals; and, as it is the expression of his thoughts and feelings by means of articulate sounds, it must have greatly varied with his changing conditions and circumstances from age to age. At first it was doubtless simple and common to all, and afterwards was broken

6. What is remarked in respect to modes of life? When does man rise highest in the scale of civilization? Describe the different states of society.

up, as tribe separating from tribe followed new pursuits and beheld new objects, and as their novel conditions of life called into activity mental faculties hitherto sluggish or dormant. Language has, therefore, come down to us in various forms, yet with certain great leading characteristics pervading them all; and these resemblances appear as frequently among the most remote tribes who have been separated as much by space as by time, as among those who have lived near each other for thousands of years.

Language has been divided into three classes,—namely, the *monosyllabic*, consisting of single words or syllables, as that of the Chinese; the *inflexional*, where the primitive words are changed or modified by additional syllables placed at the end, so as to express time, number, gender, and so forth, as in the Greek, Latin, and Sanscrit,—or where the inflexions are internal, as in a certain form of the Semitic languages; and, lastly, the languages which have inflexions, suffixes, and affixes, as in the English.

The different groups or families of languages which are allied to each other by a grammatical affinity are—first, the Indo-European, including the Sanscrit, Persian, Hindoo, Afghan, Teutonic, Slavonic, Celtic, and Iberian: second, the Semitic, comprising the Hebrew, Syriac, Arabic, and Coptic: third, the Tartarian, comprehending the languages of Central Asia, those of Lapland and Finland, and probably that of the Basques in Spain; the Malayan and Polynesian languages are also connected with the Tartar group: fourth, the Chinese and Indo-Chinese, which is monosyllabic, and embraces the languages of China, Thibet, Nepaul, Birmah, and Siam, and a portion of the Japanese language: fifth, the African family, consisting of the Negro and Kaffir languages: sixth, the American group, comprising the numerous native languages of the Western Hemisphere, which in principle of formation and grammatical construction are akin to the Tartar family of languages.

According to Adelung, there are 3664 known languages and dialects in the world, which are distributed as follows:—European, 587; Asiatic, 937; American, 1624; African, 276; and Oceanic, 240.

8. **Religion.**—The belief in a Supreme Invisible Power, who rewards the good and punishes the evil, appears to be universal among mankind; for even the Kaffirs and Bechuanas in South Africa, who have been regarded as among the most godless of the human family, possess a distinct knowledge of a Deity and of a future state, though they are destitute of any form of worship or prayer. Thus, among the most degraded races of men the light of this divine truth is perceptible, though it shines but dimly; in others, less barbarous, it is more clearly seen; and it attains its full splendor among those nations who enjoy the civilizing and ennobling influences of the Christian religion.

The various modes in which the religious principle has manifested itself have been classified as follows. The *worship of a Supreme Being*, all-powerful, all-wise, and perfectly good, as practised by Christians, Jews, and Mohammedans. *Idol-worship*, as that of the Hindoos. *Human-worship*, to which the inhabitants of Thibet are addicted, who pay divine honors to the Lama. *Animal-worship*, as that of the ancient Egyptians. *Devil-worship*, such as that of the Yazidees, and of the inhabitants of Southern India. *Fire-worship*, like that of the Parsees. The *worship of imaginary beings*, usually malignant, as practised by many of the African tribes. All these modes, except the first, are included under the name of Paganism.

On the Eastern Continent, Christianity is chiefly confined to Europe; Mohammedanism extends along the northern borders of Africa, and from Turkey in Europe through Southern Asia as far as India; while Brahminism and Buddhism, and other forms of idolatry and superstition, occupy nearly all the remaining regions. Fetichism debases nearly the whole of Africa.

On the Western Continent, Christianity prevails throughout the British Provinces, the United States, Mexico, Central America, and large portions of South America; while immense tracts in the north and northwest of North America, and the central and southern regions of South America, are still beneath the darkness of paganism. Judaism has no fixed abode, but is scattered throughout the world.

Paganism and the false religion of Mohammed still hold their sway over millions of the human race; but they are stationary in their influence. On the contrary, Christianity is progressive, and is now spreading throughout various parts of Asia, Africa, and America, as well as among the islands of the Pacific. Man, losing the knowledge of the true God, fell from his high estate, and sank into barbarism and every corrupt form of idolatry and superstition; and it is the benign mission of Christianity to raise him from his degradation and to restore him to his true position. And that it is adequate to this end has been abundantly proved, as well in modern times as in the past ages; for the Raratongans, once the fiercest cannibals of Polynesia, addicted to human sacrifices and the most licentious rites, have been changed by its influence, in the course of a generation, into a well-ordered community, with churches and schools, and a code of laws fairly administered, while the native houses vie in comfort and taste with the cheerful cottages of Christian lands.

Estimating the population of the globe as 1,000,000,000, the comparative extent of the different prevailing religions is as follows:—

Christians	340,000,000
Mohammedans	124,000,000
Pagans	530,000,000
Jews	6,000,000
	1,000,000,000

9. **Races.**—Notwithstanding the numerous diversities that exist among the human family, it is comprised under *five* great races, marked by strong peculiarities. Many nations are included in each race, differing from one another in language, manners, and mental qualities, yet bearing such a general resemblance in physiognomy and appearance as to warrant the assumed division. These races are the *Caucasian* or white race, the *Mongol* or yellow race, the *Malay* or brown race, the *American* or red race, and the *African* or black race.

10. **Caucasian.**—The Caucasian race is so called because it is supposed to have had its origin amid the Caucasian Mountains: it is also termed the Indo-European, from its diffusion over India and Europe. This group of nations extends over Turkey, Arabia, Persia, part of Tartary, Afghanistan, and Hindoostan, in Asia; over Egypt, Abyssinia, Nubia, and the Barbary States, in Africa; and comprises all the inhabitants of Europe, with the exception of the Finns, Laplanders, Magyars, and Turks proper. Within the three last centuries it has spread from Europe throughout the

CAUCASIAN.

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7. Give an account of language. How is it divided, and how are languages grouped? What is the number of known languages? 8. Do all the tribes of the human family believe in a God? Among what nations does the light of divine truth shine brightest? Mention the various modes of worship in the world. Mention the regions throughout which Christianity, Mohammedanism, and Paganism prevail. Where is Judaism found? What is said respecting the progress of these systems? What is the mission of Christianity? What is its influence on man? Cite the case of the Raratongans. State the comparative extent of the prevailing religions of the world. 9. How are mankind divided? Mention these races. 10. Give an account of the Caucasian race.

United States, and various other parts of North and South America, and over South Africa, Australia, New Zealand, and the Sandwich Isles.

The Caucasian is distinguished for a light-colored skin, varying from fair to swarthy, a ruddy complexion, abundant soft and flowing hair, an oval face, arched forehead, narrow nose, and small mouth. He is the tallest of all the races, has rounded and well-proportioned limbs, and is possessed of considerable strength, energy, and endurance.

This race comprises the most beautiful and intellectual portion of the human family. The Greeks, Georgians, and Circassians are models of perfection in form,—especially the latter, who rank highest in the scale of beauty. The most civilized and refined nations of antiquity, as the Hindoos, Egyptians, Assyrians, Greeks, and Romans, who erected mighty empires and influenced the destinies of mankind, sprang from this gifted race; and in modern times it still maintains its supremacy; for the great nations of Europe, and their descendants in the Western Hemisphere, who belong to this stock, are superior to all others in intellectual and moral development, and hold the dominion of the world.

Of this race, which numbers about 500,000,000, the Europeans, their American offspring, and the Abyssinians, are Christians; the Persians, Afghans, Arabs, and the North African races, Mohammedans; and the Hindoos, pagans.

11. **Mongolian.**—This variety is spread over the central and northern regions of Asia, China, Japan, Birmah, Siam, and Cochin China, and likewise includes all the tribes that are scattered along the shores of the Arctic Sea throughout the Eastern and Western Continents. It includes the Turks, the Mongol and Tartar tribes, the Chinese, Indo-Chinese, Japanese, Tungusians, and Samoiedes, in Asia; the Finns, Lapps, and Magyars, in Europe; and the Esquimaux, in America.

The Mongolian is distinguished for his olive-yellow skin, thin, coarse, and straight hair, square head, low forehead, broad and flat face, high cheek-bones, thick lips, and small, dark eyes obliquely set. His stature is below that of the Caucasian; but many of this race are good-looking and handsomely formed. In intellectual and moral capacity the varieties of this type differ widely; but, on the whole, they are inferior to the white race. They are ingenious and full of invention in respect to details, but appear to be incompetent to generalize. In personal appearance great differences exist; for the Esquimaux, Finns, and Lapps are diminutive and ugly, while the Kalmucks, who rove over the steppes of Central Asia, are noted for their beauty. Socially and intellectually the race attains its highest development in China and Japan. The Turks, and the Magyars,—a chivalrous and handsome people,—though both are of Mongolian origin, have been so long amalgamated with Europeans as to be more identified with Western than Eastern civilization.

MONGOLIAN.

In respect to the religion of this race, the Finns, Lapps, and Magyars are Christians; the Turks and a few of the Tartar tribes, Mohammedans; while the remainder profess Buddhism and other forms of heathenism. It numbers about 450,000,000.

12. **Malay.**—This race inhabits the Malayan peninsula and the islands of the Indian and Pacific Oceans, from Madagascar on the west to Easter Island on the east, and from Formosa on the north to New Zealand on the south. Its physical peculiarities are a high and rounded skull, low forehead, broad face, high cheek-bones, and projecting upper jaw; while the skin varies in color from a clear brown to a bright yellow, and the hair is black, straight, and shining. In stature the Malay is robust, but short, the average height of the men being about five feet two inches. This variety, which is divided into the *Malay* proper and the *Papuan*, is possessed of great activity and ingenuity. Some have made considerable advancement in social life, and are mild and gentle in their disposition; but others are treacherous and ferocious, and when maddened by narcotics recklessly attack whomsoever they meet, whether friend or foe. The Malayan nations, from their maritime position, possess much nautical skill and enterprise, and are migratory in their disposition. The Malay pirates are daring and savage, and the terror of the Indian Archipelago.

MALAYAN.

The Asiatic or true Malay possesses the distinguishing characteristics of the race; but in the Polynesian type these are somewhat modified, the skin being of a lighter color and the stature higher than in the Asiatic Malay. In the Australian type, a sub-variety of the Papuan, the difference is very marked; for the natives of this great island vary in color from a chocolate-brown to black, and have large heads, shrunken limbs, and stunted figures. They are without civilization, and are a miserable and degraded race.

The predominant religion of the Malayans is Mohammedanism. Paganism, however, is widely extended; and Christianity has been introduced among them to some extent, as in Australia, New Zealand, and the Sandwich Isles. Their number is nearly 26,000,000.

13. **American.**—This variety, which extends from north to south over the Western Continent, from about the sixty-second degree of north latitude to the Strait of Magellan, is distinguished for its reddish-brown or copper color, coarse, straight, and black hair, small, black, deep-set eyes, high cheek-bones, aquiline nose, and a somewhat low and retreating forehead.

AMERICAN.

The North American Indians are brave, vigilant, and daring, fond of war and hunting, and averse to agricultural pursuits. They are capable of noble and generous feelings, but are cruel and revengeful towards their enemies, and exhibit a wondrous endurance and stoicism under pain and torture.

The Mexicans and Peruvians, at the time of the Spanish conquest, had attained a high state of civilization: arts and agriculture flourished, and astronomy was so successfully studied that their mode of determining the length of the year was then more accurate than that of the European nations.

The natives of South America are many of them half-civilized; but the great mass of the race are heathen, sunk in the depths

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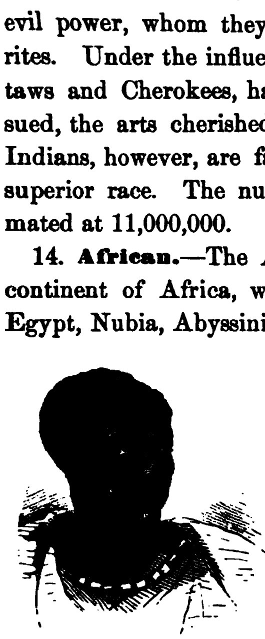
State what countries it occupies, its characteristic influence, numbers, and religion. 11. Describe in like manner the Mongolian race. 12. Where is the Malay race found? What are its characteristics? What is said of the varieties of this race? What of its religion and numbers? 13. Where is the American race found? State its peculiarities. What is said respecting the civilization, religion, and numbers of the American race?

of barbarism. The North American Indian believes in the existence of a benevolent Supreme Being; and many also recognize an evil power, whom they seek to propitiate by various superstitious rites. Under the influence of Christianity, some tribes, as the Choctaws and Cherokees, have become civilized, agriculture being pursued, the arts cherished, and general education provided for. The Indians, however, are fast waning away before the advance of the superior race. The number of the American group has been estimated at 11,000,000.

14. **African.**—The African or Ethiopian race extends over the continent of Africa, with the exception of the Barbary States, Egypt, Nubia, Abyssinia, and Cape Colony. It comprises the Hottentots, Kaffirs, Bushmen, Negroes, Mandingoes, Gallas, Tibboos, and various other African tribes. Several millions inhabit the Western Continent, a large part of whom were are enslaved. The physical peculiarities of this race are a black skin, black and woolly hair, low forehead, high cheekbones, broad and flat nose, projecting jaws, exceedingly thick lips, and curved shin. Among the varieties of this race great differences exist in respect to personal appearance; for the Kaffir is of a goodly height and well-proportioned, and has the high forehead and prominent nose of the European; others have awkward and ungainly figures and limbs, and broad, spreading feet; while the Bushmen are among the lowest forms of humanity, and the women of this tribe, according to Lichtenstein, are objects of absolute horror to Europeans. The African race has ever remained in a degraded and rude state, and for thousands of years has made no intellectual or social progress, except in a few instances, as in the case of the Foulahs, who four hundred years ago were converted to Mohammedanism, and have now large towns and schools and are noted for their commerce and agriculture. In modern times the negro has shown a capacity for self-government, on the western coast of Africa, where the once feeble colony of Liberia now takes rank as an independent nation beneath the control of the African race. The natives of Papua, or New Guinea, and the adjacent isles, though regarded by Kombst as belonging to the Malay race, are yet classed by him with the African, inasmuch as they very strongly resemble the latter in their physical peculiarities. Thus, the hair is woolly, the mouth projecting, the nose flat, the nostrils wide, the lips thick, and the skin black, while the legs are slender and have projecting heels. Some tribes in Madagascar resemble the black inhabitants of the opposite coast of Africa.



AFRICAN.

The religion of the black race in Africa, with few exceptions, is heathenism in the form of fetichism. Christianity prevails in Liberia, Sierra Leone, and other parts of the west coast, and Mohammedanism has been embraced by a few tribes. In the Western Hemisphere the African is Christianized. This variety of the human family numbers about 51,000,000.

15. **Albinos.**—A variety, not of races but of individuals, exists, which is termed the *Albinos*. In this type the color of the hair and skin is of a milky white, but the latter has occasionally a pinkish hue; the iris is of a pink color, and the pupil a vivid red. Albinos are found in all countries, but occur most frequently in hot countries: in Ceylon they are by no means uncommon.

16. **Unity of the Human Race.**—So marked and numerous are the diversities which exist among mankind, that some naturalists deny what is expressly asserted in the Scriptures,—that all nations are of one blood. But those who have made the most profound and reliable researches on this subject have arrived at the conclusion that all these diversities are quite compatible with a descent from a single stock; for they are precisely of the same nature as those which are known to occur in a species under the influence of external causes. As respects physical differences, swine, according to Blumenbach, have in some countries degenerated into races which in singularity far exceed every thing that has been found strange in the bodily varieties of the human races. Hogs with solid hoofs abound in Hungary and Sweden; and on the island of Cuba, swine of a monstrous form, and with toes nearly five inches long, are now found, which are descended from the European stock imported by the Spaniards in 1509.

The anatomical structure and physical constitution of man point also decidedly to the unity of the race: the true skin, as already stated, is alike in structure in all nations; there is the same general coincidence in respect to the age when manhood is attained, and to the period when life begins to decline; all races are subject to similar diseases, modified by varied climatic influences; and the length of life is, on an average, the same under similar conditions of existence. The resemblances which exist throughout the languages and dialects of the world attest the same fact; for the Indo-European group of nations, extending from the Ganges to the British Isles, and the Syrian and Arabian tribes, stretching from Western Asia along the northern coasts of Africa, are all bound to each other by the affinity of their languages,—though they possess every shade of color belonging to the human race, ranging from the fair and ruddy complexion, through the swarthy and olive, to the deep black. In other respects, physically as well as morally and intellectually, they are strikingly distinct.

After a full investigation in respect to the natural history of all the known tribes and nations of the world, the learned Pritchard thus remarks:—"We contemplate among all the diversified tribes of the human race the same internal feelings, appetencies, and aversions; the same inward convictions, the same sentiments of subjection to invisible powers, and of accountableness, more or less developed, to unseen avengers of wrong, from whose tribunal men cannot, even by death, escape. We find everywhere the same susceptibility, though not always in the same degree of forwardness or ripeness of improvement, of admitting the cultivation of these universal endowments, of opening the eyes of the mind to the more clear and luminous views which Christianity unfolds, of becoming moulded to the institutions of religion and of civilized life: in a word, the same inward and mental nature is to be recognized in all the races of men. When we compare this fact with the observations which have been heretofore fully established as to the specific instincts and separate psychical endowments of all the distinct tribes of thinking beings in the world, we are entitled to draw confidently the conclusion that all human races are of one species and one family."

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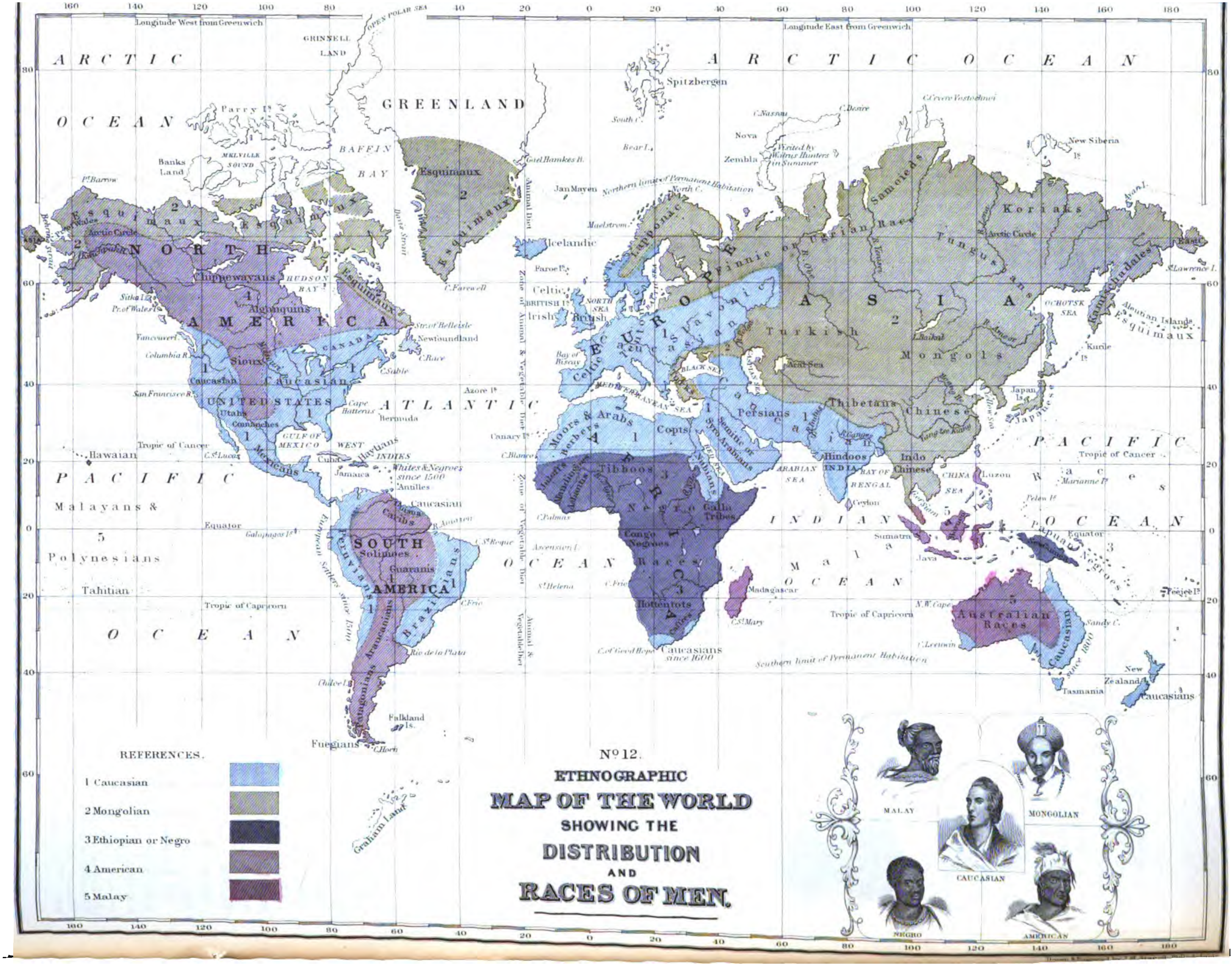
14. In what regions does the African race live? What are their peculiarities? What differences are found among them? What is said of their civilization? What is said of the natives of Papua? What is the religion of the African race? What is its number? 15. Describe Albinos. 16. What is said respecting the unity of the human race? What does Blumenbach remark? What is said in regard to anatomical structure and physical constitution? What in regard to the languages and dialects of the world? State the views of Pritchard on this point.



Nº 12.

ETHNOGRAPHIC MAP OF THE WORLD SHOWING THE DISTRIBUTION AND RACES OF MEN.

REVIEW AND MAP QUESTIONS ON LIFE AND ITS DISTRIBUTION.

What is the subject of Part Sixth?
What is said of the life of the globe and its distribution?
How is this department of Physical Geography classified?

GEOGRAPHICAL BOTANY.

What is the subject of Chapter I.?
Describe the vegetation of the tropical, temperate, and polar climes.
What is the result of the diversified conditions of vegetable life?
What is understood by the term flora?
What is the number of species?
What are the two great divisions of plants?
How are the Phanerogamia classified?
What is an exogenous plant?
What is said of this class?
Give the several illustrations.
What is an endogenous plant?
What is said respecting this class?
Describe some of the most remarkable endogens.
Describe the zones of vegetation in regard to latitude.
Show from the map (page 122) what portions of the continents, and what islands, the several zones respectively include, and what are the principal vegetable productions that flourish within each of them.
Describe the zones of vegetation as respects altitude.
Give an account from the map of the distribution of the most important plants, according to altitude, in both hemispheres.
What is said in regard to marine vegetation?
What is stated in respect to the diffusion of plants?
Describe the principal food-yielding plants which are found in the tropical and temperate climes, and point out on the map the regions where they grow.
What is said of the fruits of the extra-tropical climes?
Where does the vine flourish?
What is observed in regard to the production of bread-grains in the polar climes?
Describe the plants yielding sugar, and show on the chart where they are found.
Describe the plants producing beverages by infusion, and point out on the map the countries where they flourish.
Give an account of spice-plants.
Show on the map the localities where they abound.
What is said respecting medicinal plants and narcotics?
Point out on the map the regions where they grow.
Give an account of the chief plants that furnish clothing, and tell from the map the countries where they flourish.
Describe the plants that furnish dyes, oils, resins, and gums, and show from the map in what localities they are found.
What is said of the different kinds of woods? What of fuel?
of the vegetable kingdom as exhibiting proofs of

GEOGRAPHICAL ZOOLOGY.

What is the subject of Chapter II.?
What is Geographical Zoology?
What is observed as to the extent of animal life?
What is said regarding its distribution?
What is stated respecting the animal life of the tropic, temperate, and polar climes?
State what is said respecting the difference of the fauna at different heights above the sea-level.
What is remarked of marine life at varying depths?
What is stated in regard to the extent and diffusion of animals?
What is said of the agency of man in this particular?
How is the animal kingdom classified?
How many are the known species of the animal kingdom?
Define Mollusks and Radiates.
Mention the number of species included in these branches.
What is said respecting Infusoria?
Give an account of Articulates.
How many species are comprised in this branch?
Describe Vertebrates.
Into how many classes are they divided?
Mention them.
State what is said of Fishes, Batrachians, and Reptiles.
What is the number of the known species of fish?
Point out on the map (page 134) the distribution of the principal reptiles.
How many species are included in Batrachians and Reptiles?
What is said respecting the distribution of birds?
Mention the different orders, and the number of species.
Give an account of each order, and show from the map throughout what countries in both hemispheres the several orders are distributed, mentioning the most remarkable birds.
How are Mammalia defined?
What is the number of known living species?
Into how many orders is this class divided? Name them.
Describe the Marsupialia, and point out their distribution on the chart.
Give an account of the Monotremata and Edentata, and show on the map where the latter are found.
What is said of the Rodentia and Insectivora?
Describe some of the animals belonging to these orders.
How are they distributed?
What is said of the Cheiroptera?
Give an account of the Pachydermata, and show on the map where the most remarkable families of this order exist.
What is said of the Carnivora?
Into what two families are they divided?
Describe the most noted animals belonging to this order, and show on the map (page 138) the regions where they are respectively found.
Give an account of the Marine Carnivora, and point out on the map their localities.
What is said of the Ruminantia?
Give an account of the most important families, and point out on the map their distribution.
Describe the Quadrumana, and show from the map throughout what countries they are diffused.
What is said in regard to the Cetacea?
Show their distribution on the map.
What is said of the Dugong family?
In what order is man included?
What is said respecting the mutual dependence of plants and animals?
What of the subserviency of animals to man?

ETHNOLOGY.

What is the subject of Chapter III.?
What is Ethnology?
Give an account of man and his characteristics.
What is said respecting the number and diversities of the human race?
What are the chief diversities?
What is observed respecting physical appearance and structure?
What is one of the most marked distinctions?
What is stated in respect to modes of life?
How are mankind divided in regard to their social condition?
Describe each class.
What is said respecting language?
What of religion?
In what modes is the religious principle manifested?
What are the chief forms of religion?
What is their comparative extent?
How many races are there?
Mention them.
Describe the Caucasian race, and show from the map (page 148) throughout what countries it is diffused.
Mention its number.
Describe the Mongolian race, and point out in like manner its distribution.
What is the number of this race?
Give an account of the Malays, and show on the map the regions they inhabit.
What is their number?
Describe the peculiarities of the American race, point out on the map its geographical limits, and state its number.
Give an account of the African group, and show from the map its distribution.
How many does it number?
What is said respecting Albinos?
What is stated in regard to the unity of the human race?

THE PHYSICAL PHENOMENA OF THE UNITED STATES.

CHAPTER I.

EXTENT, COAST-LINE, INLETS, CAPES AND PENINSULAS, ISLANDS, GEOGRAPHICAL POSITION.

1. **Extent.**—The territory of the United States, including Alaska, comprises an immense region, lying between the twenty-fourth and seventy-second degrees of north latitude, and stretching westward from the sixty-sixth degree of west longitude to the one hundred and seventy-second degree of west longitude, its area being computed at 3,577,000 square miles.

2. **Coast-line and Inlets.**—One of the most striking characteristics of this country is the immense extent of its shore-line; the length of the eastern coast-line being about 7000 miles, that of the southern 3400 miles, while that of the Pacific is 3700 miles in extent,—giving a total length of 14,100 miles.

No large seas, as in Europe, pierce the mainland of the United States, but the coast-line sweeps along in curves and broken lines of varied extent, forming numerous bays, gulfs, and sounds, with their corresponding peninsulas and capes. The chief inlets on the eastern coast, beginning at the north, are the Passamaquoddy, Penobscot, and Massachusetts Bays, Long Island Sound, the Delaware and Chesapeake Bays, and the Albemarle and Pamlico Sounds. On the southern or Gulf shore are Barnes Sound, and the Tampa, Apalachee, Pensacola, Mobile, Atchafalaya, Galveston, Matagorda, Aransas, and Corpus Christi Bays.

On the Pacific coast are the Bay of San Francisco (which is entered through a narrow opening called the Golden Gate), Puget Sound, Prince William Sound, Cook's Inlet, Bristol Bay, Norton Sound, and Kotzebue Sound.

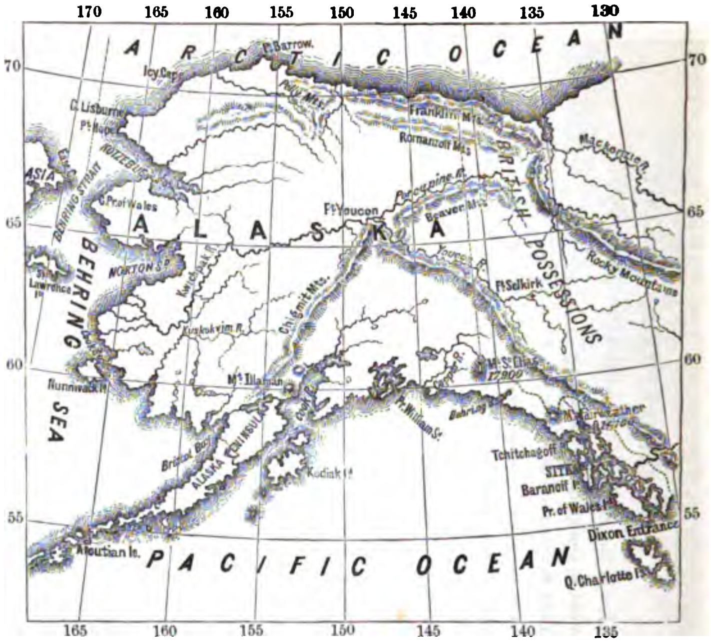
GOLDEN GATE.

3. **Capes and Peninsulas.**—The principal capes and peninsulas on the Atlantic coast, commencing as before, are Cape Ann and Cape Cod, at the entrance of Massachusetts Bay, the latter cape being the extreme point of the peninsula of the same name. To the south are Cape May and Cape Henlopen, situated on the opposite shores of Delaware Bay. At the entrance of Chesapeake Bay stand Capes Charles and Henry, and on a long reef to the southeastward of Pamlico Sound are the dangerous capes of Hatteras and Lookout, which are succeeded by Cape Fear, Cape Canaveral, and Cape Florida.

On the Gulf of Mexico, beginning with Cape Sable at the extremity of the peninsula of Florida, are Cape Romans and Cape St. Blas. On the western coast are the Point of Concepcion, and the Capes Mendocino, Blanco, Foulweather, and Flattery. These are succeeded in Alaska by the peninsula of Alaska, the Cape of the Prince of Wales on Behring Strait, Cape Lisburne, and Point Barrow, which extends into the Arctic Ocean. The latter is the most northern cape in the United States.

4. **Islands.**—Along the extended coasts of this country numerous islands are found, which for the most part are of but little importance, either in respect to size or position. On the eastern coast, the principal islands are Mount Desert, a mass of primitive rock off the coast of Maine, with an area of about 150 square miles; Martha's Vineyard and Nantucket, south of Massachusetts, and Long Island, which is separated from Connecticut by Long Island Sound, and extends one hundred and twenty miles in length with a varying breadth of from ten to twelve miles. Off the southern shore of Florida is a chain of dangerous submarine rocks and islands, called the Florida Reefs, and to the west of it lie the Marquesas Isles and the Dry Tortugas. Near the mouth of the Mississippi are the Chandeleur Islands; while Padre Island, long and narrow, skirts the southern Texan shore.

Along the Pacific coast are found the Santa Barbara Islands, lying off the shores of California; and in Alaska are the Prince of Wales Archipelago, the island of Kodiak, the chain of the Aleutian Isles, and the isle of Nunnivack. The Aleutian Isles, nearly fifty in number, sweep in a curve nearly over to Asia. They are small and destitute of trees; but poplar, beech, and cedar abound in Kodiak.



MAP OF ALASKA.

5. **Geographical Position.**—The United States, excluding Alaska, occupies the central portions of North America, and possesses a geographical position eminently favorable to the growth and rapid development of a great and powerful people. Happily situated between the extremes of heat and cold, its flora is abundant and varied, while the climate is such as conduces to physical and intellectual vigor. Its eastern coast, chafed by the Atlantic, is filled with numerous bays and roadsteads, which present every facility for commercial intercourse with the great nations of Europe; while the western shores, bounded by the Pacific, open their harbors and inlets to the rich traffic of Eastern Asia and the ocean isles.

What is the subject of this chapter? 1. What is said of the extent of the United States? 2. What of its coast-line and inlets? 3. What is said of the capes and peninsulas? 4. Describe the islands of the United States. 5. What is said of the geographical position of the United States?

CHAPTER II.

NATURAL DIVISIONS, GEOLOGICAL CHARACTER, MOUNTAINS, AND MOUNTAIN-SLOPES.

1. **Natural Divisions.**—The principal natural divisions of the United States are as follows. First, *The Atlantic Slope,* which is a long belt of land stretching from the St. Croix River on the north to the Gulf of Mexico on the south, and extending westward to the Alleghanies, never exceeding 200 miles in width, and in many places being far less. Second, *The Alleghany or Appalachian Mountain System,* which in its entire length reaches from Labrador to the Gulf of Mexico. Third, *The Mississippi Valley,* including all the region lying between the Alleghanies and the Rocky Mountains. Fourth, *The Rocky Mountain System,* with its several ranges and included table-lands. Fifth, *The Pacific Slope,* a narrow belt of land, extending from the western flanks of the Rocky Mountain System to the Pacific Ocean, and stretching from south to north in its whole extent from the peninsula of California to Mount St. Elias, and probably farther. Fifth Sixth, *The Alaska Slope,* a vast region, mostly unexplored, which descends towards Behring Sea and Strait.

2. **Geological Features.**—The United States is separated geologically into two vast divisions, the first including all those regions which consist of the more ancient formations, such as granite, traps, and the metamorphic rocks, and the second of those whose strata are of a modern origin, as limestone.

The older rocks are included within two great tracts. The eastern, which is by far the larger, extends along the Atlantic coast from the northern frontier to a point south of New York, and runs westward to the Missouri River, stretching within the Mississippi Valley in a north-and-south direction from the British possessions to Northern Texas. The other region embraces the Rocky Mountains and their spurs, but is broken up by numerous and large tracts of cretaceous and tertiary deposits.

The more modern formations are embraced in three areas,—the eastern and western, which skirt respectively the Atlantic and Pacific slopes, and the central district, which is vastly the largest of the three, extending westward from Georgia to the table-lands of Mexico, northwestward to the Cascade chain in Oregon, and northward beyond the plain of the Upper Missouri to an undefined limit. The eastern and central portions of this immense area are chiefly of cretaceous deposits, broken up here and there by the older rocks; the western division, lying between the Rocky Mountains and the Sierra Nevada, is considerably diversified by mountain-spurs and offshoots belonging to the more ancient formations.

3. **Mountains.**—The United States is traversed by three mountain-systems, viz.:—the Alleghanies or Appalachian chain on the east, and the Rocky Mountain and Pacific systems on the west. The *Alleghany System,* which consists of many parallel ridges, stretches southwesterly from the Gulf of St. Lawrence to the northern regions of Georgia and Alabama, having a breadth varying from 150 to 200 miles, and a mean elevation of 2500 feet; though some of the higher ranges rise to the altitude of from 3500 to 4000 feet above the sea, and several of the bolder mountain-masses attain much loftier heights. It is divided into two groups, the northeastern and southwestern, separated by the Hudson and Mohawk Rivers.

Beginning with the *northeastern group,* the Appalachian chain, entering the United States from Canada, forms a part of the western boundary of Maine, and, extending into Vermont, assumes the name of the Green Mountains, which are thence continued through Massachusetts and Connecticut to New York, where they are severed by the Hudson to the tide-level. This range attains its highest elevation in Vermont, where the boldest crest exceeds 4000 feet in altitude. In proximity with this chain are several lofty and isolated mountain-masses, the chief of which are the White Mountains in New Hampshire, and the Adirondacks in New York. The former are remarkable for their sublime scenery, and, though scarcely a degree in length, their crests are among the highest of the Appalachian system, Mount Washington having an altitude of 6234 feet and Mount Adams of 5960 feet above the ocean.

MOUNT WASHINGTON.

The Adirondacks, which consist of chains of hills and irregular crests, rise in Mount Marcy to the height of 5500 feet. Isolated mountain-groups occur in Maine, the loftiest of which is Mount Katahdin, 5360 feet high.

The *southwestern group,* or Alleghanies proper, extend from the Hudson and Mohawk Rivers to Northern Alabama and Georgia, in three great parallel ranges. The most westerly embraces the Alleghany Mountains in Pennsylvania and the Cumberland Mountains in Tennessee; the middle is a broad belt of long and narrow ridges, separated by valleys of a similar character, and broken by transverse defiles, which afford a passage for the streams; while the southeastern, which is the most beautiful and picturesque of the three, extends through Virginia under the name of the Blue Ridge, and is continued into the Carolinas, Georgia, and Tennessee. Between the Blue Ridge and the middle belt of the Alleghanies lies the level and fertile valley of Virginia, abounding with the most enchanting and picturesque scenery. The higher crests of the Appalachian zone are found in North Carolina, where Mount Buckley rises to the altitude of 6775 feet above the sea-level.

The Ozark Mountains extend southwesterly, in a direction parallel with the Alleghanies, from near the Osage River in Missouri to the Red River.

4. The *Rocky Mountain System* is a part of that immense mountain-zone, already described, which stretches from the Arctic Ocean to the Strait of Magellan. It is a complex system of ridges, table-lands, and valleys, but consists for the most part of two, and in some regions

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What is the subject of Chapter II.? 1. What are the natural divisions of the United States? 2. What is said respecting the geological features of the United States? 3. Describe the chief mountain-ranges. Describe the Appalachian chain. What is said in regard to the Ozark Mountains?

of three, principal chains, running nearly parallel to each other, with bold offshoots and broken and irregular crests, that rise to very lofty heights.

The *eastern* chain rises in precipices from the margin of the great eastern table-land, while vast rocky spurs are here and there pushed forward into the plateau. This range includes some of the highest peaks of the whole chain, as Long's and Pike's Peaks, which are each about 12,000 feet above the sea-level; while north of the Nebraska River the Wind River Mountains tower, in Frémont's Peak, to the altitude of 13,750 feet above the ocean.

Near the sources of the Arkansas the Rocky Mountains stretch southward, in numerous parallel ranges, such as the Sierra Blanca and the Zuñi Mountains. Another chain, formed by the Bear and Wasatch Mountains, diverges southward from the main range near the head-waters of the Columbia River, and traverses the great central plateau to the confines of Mexico.

5. To the west of the Rocky Mountains, and separated from them by the Great Interior Basin and other table-lands, is the *Pacific System*, which runs along the shores of the Pacific at a distance of about one hundred and seventy-five miles. This chain consists of the Sierra Nevada and Coast Mountains of California, and the Cascade Range of Oregon.

Diverging from the Coast Mountains about the parallel of 35°, the Sierra Nevada, with its rugged crests, stretches northerly, and at about the forty-second degree of latitude loses somewhat of its bold features. The Coast Mountains, from their point of divergence from the Sierra Nevada, extend in a broken line through California, Oregon, and Washington, as far as Vancouver Island, closely skirting the Pacific shores throughout the whole distance. Between these chains lies the famous gold-bearing valley of California, five hundred miles in length, and from eighty to one hundred and fifty miles in breadth. The Cascade Range, flanked by the Coast Mountains and the Sierra Nevada, begins near the parallel of 40°, and, extending northward through Oregon, Washington, and British Columbia, seems to be prolonged in Alaska and in the Chigmit Mountains.

The central crests and elevated peaks of the Pacific system rival and even surpass in height the noble ranges and summits of the Rocky Mountain chains,—Mounts Hood and St. Helens, in the Cascade Range, rising to the respective heights of 14,000 feet and 13,300 feet above the sea-level; while Mount St. Elias, in Alaska, lifts its head to the altitude of 17,900 feet above the ocean.

The Rocky Mountain zone, including the Pacific system, is the highest chain in the United States, and divides their surface into two vast inclined planes, the land, though here and there swelling into plateaus and rising into mountains, having a general descent on the west towards the Pacific, and on the east towards the Atlantic.

6. **Mountain-Slopes.**—The chief mountain-slopes of the United States are the Atlantic and Pacific slopes, and that of Alaska.

The *Atlantic slope*, which stretches from the northeastern frontier to the Gulf of Mexico, is a long and slender belt of land inclining southeasterly from the base of the Appalachian chain, and consists of two divisions, the northern and the southern. The northern extends southward to the valley of the Hudson, ranging in width from fifty to one hundred and fifty miles, and has a diversified and mountainous surface.

The southern section, prolonged from the Hudson to the Gulf of Mexico, expands southward to an average width of two hundred miles, excluding the peninsula of Florida. It consists of a seaboard plain and an upper belt, which forms the true slope. In the Middle States this latter region is one of the richest and most attractive districts on the continent, the surface either expanding into broad, fruitful, and salubrious valleys, or swelling into forest-crowned ranges of moderate height; while the soil is everywhere well watered and fertile. South of the Potomac its natural features are less diversified, and the soil is of a poorer quality.

The *Pacific slope* includes that long and narrow region which lies between the western shores of the United States and the Pacific range. From the southern frontier of California to about the 35th degree of latitude, the base of the Coast Mountains forms its eastern boundary; but beyond this point it widens, and is composed of three parallel belts, which extend back from the ocean, one behind the other, as far as the Sierra Nevada. The same general structure is preserved beyond California, through Oregon and Washington, the average width to the parallel of 60° being about one hundred miles. Besides the rich valley of California, lying between the Sierra Nevada and the Coast Range, many beautiful and fertile valleys are enclosed between the latter chain and the Pacific shores.

The *Alaska slope* has been so far explored that it is known to be drained by several rivers, that have their sources in the Rocky Mountains and other minor ranges.

CHAPTER III.

TABLE-LANDS, PLAINS, AND VOLCANOES.

1. **Plateaus.**—The principal table-lands of the United States are the *eastern* and *western* plateaus of the Rocky Mountains.

2. The *eastern* consists of part of that immense belt of lofty lands which runs northward, parallel to the chain of the Rocky Mountains, from Texas to the Bear Lake. This great table-land, rising in the direction of its length from its southeastern border near the Lower Rio Grande to the Upper Missouri, ascends in well-defined terraces and slopes from the eastern plain to the foot of the

SCENE ON THE TEXAN PLAINS.

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4. Describe the Rocky Mountain system. 5. Describe the Pacific system. 6. Mention the mountain-slopes of the United States. Describe the Atlantic slope. Describe the Pacific slope. What is said of the Alaska slope?

What is the subject of Chapter III.? 1. What are the principal table-lands of the United States? 2. Describe the eastern plateau of the Rocky Mountains.

Rocky Mountains. One of these terraces, which extends from the river Pecos to the Black Hills of the Missouri, is so bold and prominent that it may be regarded as dividing the table-land into two plateaus, the upper or *western*, and the lower or *eastern*. The latter is 2500 feet above the sea-level, while the former is 1000 feet higher at its eastern margin, and has an average breadth of more than 200 miles. Westward it rises still higher, till its broad expanses on the flanks of the Rocky Mountains attain to altitudes varying from 5000 feet to 6000 feet above the sea.

Within each of these plateaus are vast tracts of sandy and sterile soil, some of which are destitute of trees and shrubs. Others have but a scanty growth of herbage; while some are almost entirely deprived of water, and assume the character of deserts.

One of these desert wastes, lying partly in Texas and partly in New Mexico, is thus described by Captain Marcy. "This barren table-land extends in a southerly course from the Canadian River to near the confluence of the Pecos with the Rio Grande, some four hundred miles, between the 32d and 37th parallels of north latitude. It is in places nearly two hundred miles in width, and is embraced within the 101st and 104th meridians. Its approximate elevation above the sea, as determined by the barometer, is 2450 feet. It is very smooth and level, and spreads out in every direction, as far as the eye can see, without a tree, shrub, or any other herbage. It is an ocean of desert prairie, and no living being permanently resides upon it. The almost total absence of water causes all animals to shun it; and the Indians do not venture to cross it, except at two or three points where they find a few ponds of water. I was told in New Mexico that many years since the Mexicans marked out a route with stakes across this plain where they found water, and hence the name by which it is known throughout Mexico, of El Llano Estacado, or the Staked Plain."

This table-land is separated from the fertile plains of Texas by a belt of woodland, called the Cross-Timbers, about twenty-five miles wide, and extending from the Brazos River to the Arkansas River, a distance of more than four hundred miles.

The upper plateau is more arid than the lower, which in its middle and southern portions possesses a denser verdure and broader belts of trees. The edge of this lower table-land, in about the 100th meridian, divides the fertile lowlands from the less productive and arid zone of the plateau.

3. *The western plateau* is a portion of that vast range of table-lands which extends from the Gulf of California to the Arctic Ocean, flanked on the west by the Pacific chain and on the east by the Rocky Mountains. It is a lofty region, having a mean altitude above the sea of 5000 feet, and comprises various table-lands and elevated valleys. Some of these are rich and fertile, as the "Parks," whose beautiful expanses, stretching for leagues, are covered in summer with a sea of waving grass; while others are dry, saline, and desert wastes.

The western plateau is naturally divided into three principal regions:—a central tract; a southern, separated from this by the Wasatch Mountains and a high belt of land extending to the Sierra Nevada; and, lastly, a northern tract, parted from the central by the Blue Mountains.

The central region, or the Great Interior Basin, lies, as already stated, between the 37th and 44th degrees of north latitude, and has an average diameter of about five hundred miles. It consists in the main of vast arid steppes, many of which are saline; but it also possesses beautiful fertile plains. This region is girdled by mountains, and a series of parallel ranges extend across it from the Rocky Mountains to the Sierra Nevada. All its rivers, of which the chief is the Humboldt, flow into lakes which have no outlet to the sea.

The southern division presents less of a desert character, and contains many well-watered tracts and rich upland valleys. Here is found the great valley of San Luis, from forty to seventy miles wide, drained by the Rio Grande, and having an elevation of 7567 feet above the sea. The northern section, descending to the east and north, is characterized in the basin of the Columbia by rugged volcanic table-lands, though beautiful and verdant valleys are not unknown. In Alaska the descending uplands are drained by the Porcupine and Youcon Rivers, the main branches of the Kwichpak.

The western plateau, regarding it as limited on the north by the British possessions, has been estimated to have an area of 250,000 square miles. A remarkable characteristic of this region is its river-gorges, or cañons, which have been channelled by the mountain-streams to the depth of thousands of feet below the general surface of the table-lands.

4. **Plains.**—The principal plains of the United States are the Great Central Plain, or Mississippi Valley, and the Atlantic Plain, which differ exceedingly from each other in their relative magnitudes.

The *Great Central Plain* lies between the Alleghanies and the eastern plateaus of the Rocky Mountains, and stretches from north to south from the British Possessions to the Rio Grande. Within its limits are included the lower portions of the Texan slope on the south, the basin of the Red River on the north, and on the north and northeast a part of the St. Lawrence basin. This immense tract is separated into two great divisions by the Mississippi River, which, flowing southward, drains nearly its whole extent.

The eastern division is nearly a thousand miles long, and extends from the Mississippi to the base of the Alleghanies, a distance of about three hundred miles. It is a magnificent, undulating country, well watered, and blest with a rich soil and favorable climate. Formerly it was almost covered with dense and noble forests, interspersed with grassy prairies; but the woods have now to a great extent disappeared, and throughout this region the fertile land teems with abundant crops of the different grains and products adapted to its varying climates.

Westward of the Mississippi the character of the surface changes, spreading out into slightly rolling or perfectly level prairies and savannahs, which are covered with long grasses variegated with flowers, and for the most part are scarcely marked by the presence of a tree or shrub, save on the banks of streams, which are fringed with azaleas, kalmias, and rhododendrons.

On the rich and flowery prairies of Texas, trees are more frequent, and these beautiful expanses are studded with groups of the magnolia and tulip trees, and even long belts of forest occur, as already stated; while in the northern portion of the westward division the oak and black walnut are seen. The central plain maintains its fertile character to the edge of the lower eastern plateaus, the meridian of 100° being the approximate division between the productive plains and the arid and sandy table-land. Abounding in the elements of material wealth, and possessing a salubrious climate, this immense plain bids fair to become one of the most important centres of influence in the Western Hemisphere.

Describe El Llano Estacado and the Cross-Timbers. What is said of the upper plateau? What meridian divides the fertile plains from the dry plateau?

3. Describe the western plateau. 4. Name the principal plains of the United States. Describe the Great Central Plain.

The *Atlantic plain*, lying between the Atlantic slope and the sea-coast, is a narrow belt of land extending from Massachusetts to the Gulf of Mexico: it never rises more than one hundred feet above the sea-level, and is intersected by numerous tidal creeks and inlets. The northern portion is for the most part sandy, while the southern is quite swampy; and in North and South Carolina the moist lowlands are well adapted to the cultivation of rice. In North Carolina a sandy region, which is covered with valuable forests of pitch-pine, extends more than fifty miles back from the coast.

5. **Volcanoes.**—The northwestern portion of the United States is decidedly volcanic in its character; for it contains about forty volcanoes, the far greater part of which are in activity. Mount Hood, in Oregon, and Mount St. Helens, in Washington, have both been seen in a state of eruption; and in the Aleutian Isles, thirty-five volcanoes, nearly every one of which is active, form a main link in that vast chain of fire that girdles the Pacific Ocean.

CHAPTER IV.

LAKES AND RIVERS.

1. The great lakes Superior, Michigan, Huron, Erie, and Ontario, comprising together an area of 94,000 square miles, contain most of the lake-waters of the United States. They form an immense chain of inland seas upon the northern frontier, the boundary-line between the Dominion of Canada and the United States passing through the middle of all, with the exception of Lake Michigan, which lies entirely within the United States. Besides this system, many small and less important lakes are scattered throughout the latter country.

Beginning at the north, Lake Superior is seen spreading out its vast expanse of waters. It is the largest of all the lakes in the chain, having an area of 31,500 square miles, and a circumference which has been estimated at 1700 miles. Its waters, which are very pure, transparent, and deep, flow into Lake Huron on the south, through the river St. Marie, about fifty miles long.

Lake Huron has an area of 23,100 square miles, and a depth of 1800 feet: it is quite irregular in form, and contains many bays and islands. Through the Strait of Mackinaw on the west, it receives the waters of Lake Michigan, and on the south flows into Lake Erie through the small lake and river of St. Clair, which together are about sixty miles long.

Lake Michigan is almost exactly the size of Lake Huron, but is only half as deep. At its northern extremity is a large bay, called Green Bay.

Lake Erie is 7800 square miles in extent, and about two hundred and seventy feet deep. Its own waters, swelled by the influx from the great upper lakes, descend by the Niagara River into Lake Ontario, forming in their passage the renowned cataract of Niagara. It is also artificially connected with Ontario by the Welland Ship Canal.

Lake Ontario, the smallest of all the lakes in this chain, contains 6900 square miles, and has a depth of five hundred feet. From its northern extremity issues the noble river St. Lawrence, whose broad waters just below the lake are diversified by the enchanting scenery of the Thousand Isles.

The chain of the northern lakes, on account of their immense extent, deep water, and extensive coast-line, which has been computed to be more than 3000 miles long, afford great facilities for internal navigation, and a vast commerce has arisen upon their waters. They possess, however, but few good harbors, their shores in many parts are rocky and dangerous, and they are subject to fierce and terrific storms. A slight tide has been observed in Lake Michigan.

LAKE CHAMPLAIN.

Lake Champlain is a beautiful expanse of water, lying between the States of New York and Vermont. It is about one hundred and twenty miles long, and is diversified by more than sixty islands. It discharges its waters northward by the river Richelieu into the St. Lawrence, and is connected by the Champlain Canal with the Hudson River and Erie Canal.

Lake George, set like a gem amid the mountains, is a charming lake, lying near Champlain, into which it flows at Ticonderoga. It is thirty-six miles long, and its waters, which are remarkable for their transparency, are studded with numerous and beautiful islands.

In the interior of the State of New York are many small and lovely lakes, such as those of Cayuga, Seneca, and Oneida.

Numerous minor lakes are found in Northern New England, the chief among which are Moosehead and Chesuncook Lake in Maine, and in New Hampshire the lakes Umbagog, Connecticut, and Winnipiseogee, which are noted for the charms of their scenery. In Florida is a small lake which has received the name of Okeechobee.

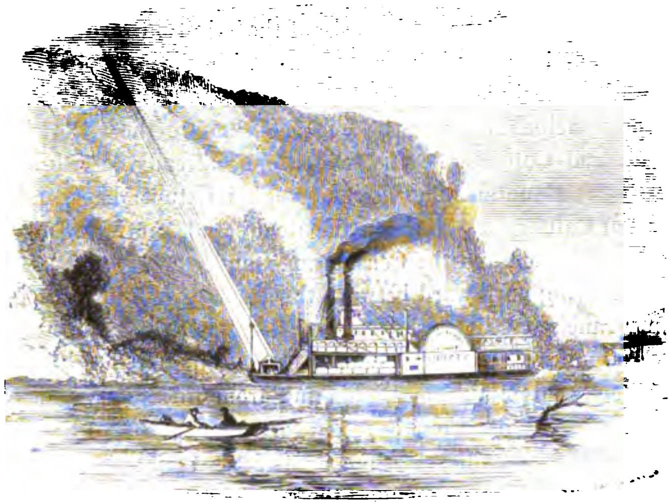
2. In the Great Interior Basin salt lakes occur, the largest of which is the Great Salt Lake, 291 miles in circumference, and having an area of 1875 square miles. Its waters are almost saturated with salt, and it contains many islands, some of which reach an altitude of from 800 to 1000 feet above the general level of the lake. On this table-land is also situated Lake Utah, a beautiful sheet of pure fresh water, thirty miles long and about ten miles broad, which flows into the Great Salt Lake through the river Jordan, fifty miles long.

In Oregon, northward from the point where the Klamath River breaks through the Cascade Range, to the gorge of the Columbia,

Describe the Atlantic plain. 5. State what is said of the volcanoes of the United States.

What is the subject of Chapter IV.? 1. What is the lake-system of the United States? Describe the chief system. What is said respecting the facilities for inland commerce afforded by the great lakes? Describe Lake Champlain and Lake George. What is said respecting the small lakes in the interior of the State of New York? What of those of Northern New England and Florida? 2. What lakes occur in the Great Interior Basin? Describe the Great Salt Lake and Lake Utah. What is said of the Oregon lakes? Describe Lake Majesty.

small bodies of water exist, none of which equal, however, in the grandeur of their scenery, a remarkable expanse of water, called Lake Majesty, which is situated not far from Fort Klamath. According to the account of Captain F. B. Sprague, who visited this lake, it is nearly circular, and has a diameter of from seven to eight miles; it is surrounded by precipices of volcanic rock seven or eight hundred feet in height, which are almost perpendicular, the shores of the lake being reached with great difficulty. The waters are as clear as crystal; and near the western margin is an island about half a mile in diameter, shaped like the frustum of a cone, and with a depressed summit, in which there appears to be a crater. The whole surroundings of the lake, in the opinion of Captain Sprague, prove it to be the crater of an extinct volcano.



ALABAMA RIVER.

3. **Rivers.**—The rivers of the United States are principally comprised under seven systems,—six oceanic and one continental. The first class consists of the Hudson Bay or Red River system, and the Atlantic, Gulf of Mexico, Pacific, Behring, and Arctic systems, each being designated by those portions of the main ocean into which their respective rivers flow. The second class embraces the rivers of the Great Interior Basin.

The *Hudson Bay System* comprises the few streams that belong to the basin of the Red River of the North, and which empty through Lake Winnipeg into Hudson Bay.

The *Atlantic System* consists, in the first place, of those small rivers in the United States which are connected with the Basin of the St. Lawrence and reach the Atlantic through this noble stream, and, secondly, of all the rivers of the eastern coast flowing directly into the ocean.

4. Beginning with the latter division on the north, the first river of importance is the Penobscot, in Maine, whose principal branch rises in the western part of the State. This river empties into the Bay of Penobscot, and is navigable for ships as far as Bangor, about fifty miles from its mouth. Beyond this is the Kennebec, which springs in part from Moosehead Lake. Next follows the Merrimac; while farther south the Connecticut, the beautiful river of New England, flowing down through its lovely valley, enters Long Island Sound after a course of more than 400 miles.

To this succeeds the noble Hudson, which, rising in the mountainous region west of Lake Champlain, and receiving the waters of the Mohawk from the west, thence flows onward to the sea through the charming rock-scenery of the Highlands. It is not only navigable to a distance of about 160 miles from its mouth, where the great emporium of New York is situated, but is also connected with the northern lakes by the Erie Canal, and by the Champlain Canal with the lake of the same name. Thus linked with the fertile regions of the west, its waters have become the seat of an immense traffic.

THE HUDSON, FROM WEST POINT.

South of the Hudson is the Delaware, which has its source in the Catskill Mountains and discharges its waters into the Delaware Bay. It is navigable for the largest vessels as far as Philadelphia.

Beyond this stream is the beautiful Susquehanna, which, rising in the Otsego Lake in New York, flows through Pennsylvania, and, gathering in the waters of the West Branch and Juniata, at length empties into Chesapeake Bay. Into this bay also enters the Potomac, which has its source in the Alleghany range, and, after uniting with the Shenandoah, flows by the city of Washington.

To this succeeds in Virginia the Rappahannock, and next the James River, which rises amid the western ranges, and, after piercing the Blue Ridge, passes by Lynchburg and Richmond, and enters the Atlantic, through Hampton Roads, in Chesapeake Bay. Farther on are the Roanoke and Cape Fear Rivers, in North Carolina, the latter being the most important of all the rivers flowing entirely within this State.

JAMES RIVER.

To the south of this are the Great Pedee, Santee, and Savannah Rivers, the last forming the boundary between South Carolina and Georgia. Beyond these are the Ogeechee and Altamaha Rivers.

On account of the proximity of the Alleghany range to the ocean, the rivers of the Atlantic system have no great length. In their upper courses, where they descend the Atlantic slope, they are broken by rapids and falls, which afford an immense extent of water-power for manufacturing purposes; but in their lower courses, where they traverse the narrow Atlantic plain, they are for the most part navigable only for short distances from their mouths.

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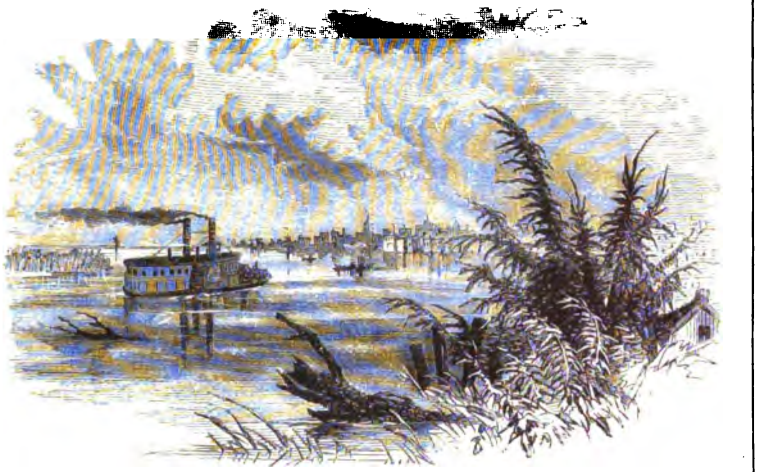
3. What are the principal river-systems of the United States? Describe the Hudson Bay system. 4. What is said of the Atlantic system? Mention its rivers.

5. Passing around the peninsula of Florida, the first of the principal rivers of the *Gulf System* that presents itself is the Appalachicola, which is formed by the union of the Chattahoochee and Flint Rivers, the former of which rises in the Alleghanies and is navigable for boats for nearly four hundred miles from the Gulf. Westward of this is the Alabama River, which has its source in the Alleghany ranges of Georgia, and, uniting with the Tombigby, forms the Mobile River, which enters into Mobile Bay.



MOBILE BAY.

Beyond this stream the Mississippi pours into the Gulf its mighty flood, gathered by its numerous tributaries from that vast region known as the Mississippi Basin, and which comprises by far the larger portion of the Great Central Plain.

This noble river, rising in the swell of land west of Lake Superior, flows southward from Lake Itasca, and at the distance of about four hundred miles from its source occur the Falls of St. Anthony, where the stream, three hundred and fifty yards wide, forms a cataract seventeen feet in height. Not far from this are the Minnehaha Falls, a beautiful and picturesque cascade forty feet high. Flowing onward amid the most charming scenery, the Mississippi receives in succession the waters of the Minnesota, Wisconsin, Iowa, Des Moines, and Illinois Rivers; and just below the latter the mighty Missouri comes in from the west, after its long course of 2800 miles from its source in the Rocky Mountains. At the Gates of the Rocky Mountains, where this noble stream bursts through these lofty ranges, it presents a scene of surpassing sublimity, rushing for nearly six miles through a chasm 150 yards wide, whose rocky walls rise to the height of 1200 feet above the bed of the stream.

MINNEHAHA FALLS.

About one hundred miles below this gorge are the cataracts of the Missouri, where the river, in a succession of rapids and cascades, is said to descend 357 feet in eighteen miles. Many large rivers, as the Yellow Stone, Platte, and Kansas, are affluents of the Missouri, which is navigable for small steamers as far as Fort Benton in Montana, a distance of more than 2000 miles from its mouth.

Beyond the Missouri, the beautiful Ohio, formed by the union of the Alleghany and Monongahela Rivers, and swelled by the waters of the Kentucky, Wabash, Cumberland, the winding Tennessee, and other affluents, enters the Mississippi from the east; while lower down, on the west, the Arkansas and Red Rivers, descending the western mountain-ranges, add their tributary floods to the mighty stream, which enters the Gulf of Mexico after a course of 4100 miles, including that of the Missouri. The remaining rivers of the Gulf system belong to the Texas slope, and consist of the Trinity, Brazos, Colorado, Guadalupe, and Nueces Rivers, together with the Rio Grande and its northern branches.

6. The principal rivers of the *Pacific System* are the Colorado, Sacramento, and Columbia. The Colorado, as already described, rises in the Rocky Mountains and flows through its stupendous cañons to the Gulf of California. The Sacramento descends southward between the Sierra Nevada and the Coast Range, and, after joining the San Joaquin, flowing northward between the same ranges, enters the Bay of San Francisco. Both these rivers are navigable a distance of nearly 100 miles from their mouths. The Columbia has its sources in the Rocky Mountains, and, plunging from these lofty ranges in cataracts and rapids through rocky gorges more than 1000 feet in height, enters the Pacific, after a course of 1200 miles.

7. The *Behring System* includes the rivers in Alaska that flow into Behring Sea. The chief of these is the Kwichpak, which has been explored for the distance of 1000 miles, and is estimated to be 2500 miles long: it rises in the Rocky Mountains, and its main branches are the Porcupine and Youcon Rivers. The *Arctic System* embraces a few streams in Alaska which enter the Arctic Sea, and in regard to which little is known beyond their existence.

8. The *Continental System* of the Great Interior Basin includes the small streams that empty into the lakes of this region and have no communication with the ocean. The chief river of this system is the Humboldt.

CHAPTER V.

METEOROLOGICAL PHENOMENA, CLIMATE, AND NATURAL PRODUCTIONS.

1. **Meteorological Phenomena.—Temperature.**—As the United States are situated between the 24th and 72d degrees of north latitude, they are subject to all those variations of temperature in latitude which prevail from near the tropical to the Arctic regions.

The same thermal range also exists in altitude; for the southern shores of this country are bathed in the warm waters of the Gulf of Mexico, while its loftiest peaks are crowned with perpetual snow. The highest mean annual temperature in the United States occurs at the military post of Key West in Florida, where from the observations of fourteen years a mean annual temperature of 70°.51 Fah. has been deduced. The lowest mean yearly temperature, according

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5. Describe the principal rivers of the Gulf System. 6. Describe the Pacific System. 7. What is said of the Behring and Arctic Systems? 8. What of the Continental System of the Great Interior Basin?

What is the subject of Chapter V.? 1. What is said respecting the temperature of the United States? Where does the highest mean annual temperature occur? Where the lowest?

to Richardson, is at Youkon, in Alaska, the average height of the thermometer during the year being only 16°.92 Fah.

2. The following table exhibits the mean annual temperature of twenty-four important localities in the United States:—

	Mean Annual Temperature.	Latitude.	Longitude.
Brownsville, Texas.	73.7° Fah.	25° 54′ N.	97° 26′ W.
Galveston, Texas.	69.4°	29° 18′	94° 46′
St. Augustine, Florida	69.6°	29° 48′	81° 35′
New Orleans	69.9°	29° 57′	90°
Savannah.	67.2°	32° 05′	81° 07′
Charleston.	65.9°	32° 45′	79° 57′
Memphis.	60.8°	35° 08′	88°
Richmond.	56.2°	37° 04′	77° 31′
San Francisco	57.2°	37° 48′	122° 20′
St. Louis.	55.4°	38° 37′	90° 16′
Washington City	56°	38° 53′	77° 02′
Cincinnati.	53.8°	39° 07′	84° 30′
Philadelphia (Girard College)	51.6°	39° 57′	75° 13′
New York	51.7°	40° 42′	74° 01′
Chicago.	46.7°	41° 52′	87° 35′
Fort Laramie.	51.1°	42° 12′	104° 47′
Detroit.	47.2°	42° 20′	82° 58′
Boston	48.9°	42° 21′	71° 03′
Portland (Marine Observatory)	42.9°	43° 40′	70° 14′
Oregon City.	54.8°	45° 20′	122° 30′
Mackinaw	40.6°	45° 51′	84° 51′
Astoria (Oregon).	52.2°	46° 11′	123° 48′
Fort Benton.	48.2°	47° 50′	110° 36′
Sitka (Alaska).	42.6°	57° 03′	135° 18′

3. The departures of the yearly isothermals from the parallels of latitude are of varying extent in different parts of the country.

Within the Mississippi Valley east of the 95th meridian, except in the region of the great northern lakes, these departures are but small, and places which are situated in the same latitude have nearly the same mean yearly temperatures, as is evident from the table and the chart. On the east, the chain of the Alleghanies produces by its elevation marked deviations in this particular. On the west, such is the effect of the lofty system of the Rocky and Pacific Mountains, with their dry plateaus, and so great are the influences of the currents and winds of the Pacific Ocean, that the isothermal curves range approximately with the meridians instead of the parallels, and sometimes form a double curve. Thus, for instance, the isothermal of 45° passes near Dover in New Hampshire, and, sweeping westward, rises into the British Territory north of Montana; then, turning southward, it extends as far as New Mexico, where, bending again, it runs northwest to a higher latitude than before. The table presents a similar illustration, the mean annual temperature of Sitka being two degrees higher than that of Mackinaw, though the latter locality is more than eleven degrees south of the former.

4. **Winds.**—The United States are situated within the region of variable winds, the general direction of which, as given on page 91, is 87¾° west of south. This prevalent current is a portion of the upper constant southwesterly wind of the Northern Hemisphere,—the reverse current of the northeast trade,—which, sinking in temperature, descends, and, bending to the east, becomes in part a surface-wind.

Throughout the whole coast of the Gulf of Mexico southerly winds prevail, which are stronger and more continuous west of the Mississippi than they are to the east of this river. In Texas the southeasterly wind possesses somewhat the character of a monsoon, alternating with the Northers, which are the storm-winds of the coast.

Sweeping up the Mississippi Valley from the Gulf, the soft southerly winds spread their genial influences far and wide over the Great Central Plain, and at length blend with the constant atmospheric current flowing in an easterly direction.

Northwesterly winds are very frequent throughout the United States. They are regarded as portions of the prevalent polar currents from a northeasterly quarter, which are deflected from their courses by the flanks of the Rocky Mountains. Turned by these barriers, they sweep, keen and dry, across the land, and exert a decided influence upon its climate.

To the same origin are attributed the cool and humid northeast winds which prevail along the Atlantic slope and are especially marked in New England. Land and sea breezes occur, with more or less striking alternations, throughout the whole extent of the Gulf and Atlantic coasts; and on the Pacific shores in California there is a remarkable land-wind during the summer, attended by clouds of mist.

Tornadoes of limited extent, but of terrific violence, are by no means uncommon in the United States; and the eastern coast and its adjacent waters are swept from time to time by the devastating cyclones of the Atlantic.

5. **Rains.**—In regard to the distribution and quantity of rain, the United States are classed under four distinct regions. The first includes the Atlantic Slope, and the Central Plain as far west as the edge of the eastern table-land of the Rocky Mountains; the second comprises the Rocky Mountain zone, with its plateaus, and is limited on the west by the crests of the Sierra Nevada and Cascade range; the third embraces the Pacific Slope; and the fourth, the region of Southern Alaska.

In the first division the rains fall in copious measure, and are distributed throughout the year; and the winds which here prevail reveal the cause of this full and continuous supply. The warm and moist southerly winds from the Gulf, and the constant current from a southwesterly quarter, moving onward into the higher latitudes, are in perpetual conflict with the cold and dry winds from the north and northwest; and rains and storms necessarily ensue. The cool and humid northeast winds, uniting also with the southerly breezes, cause a large precipitation of moisture on the eastern shores. This whole district is for the most part blessed with abundant rains; for the annual rainfall on the Atlantic coast from Florida to Maine varies from sixty-three to forty inches, and in the interior, from the Gulf of Mexico to Wisconsin, from sixty-three to thirty inches.

6. The Rocky Mountain district is an arid region, in which the rain appears to be distributed throughout the seasons north of about the 35th parallel, though it falls in very small quantities. The annual rainfall in the regions most favored with moisture is seldom more than about twenty inches, as at Fort Laramie in Dakota, and Santa Fé in New Mexico, in which localities the annual amounts of rain are respectively 19.98 and 19.83 inches; while in the Great Interior Basin it sinks to about three inches. The causes of the aridity of this section are to be sought in the high mean temperature it possesses, notwithstanding its elevation, and in the fact that the lofty

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2. State the mean annual temperature of the several localities given in the table. 3. State what is said respecting the departure of the isothermals from the parallels of latitude, and give illustrations. 4. What is said respecting the winds of the United States? What winds prevail along the Gulf coast? What is the origin of the northwesterly winds of the United States? What is said respecting land and sea breezes, tornadoes and cyclones? 5. How are the United States divided in regard to the distribution and quantity of rain? Name the divisions. Describe the first. 6. What is said respecting the Rocky Mountain district?

mountain-ranges on the west arrest the constant and humid current which flows easterly over the Pacific Ocean.

7. The rains of the Pacific Slope, south of the parallel of forty-one degrees, appear to be periodical in their character, by far the greater part descending during the winter and spring. Thus, at Fort Humboldt in California, situated in 40° 46′ north latitude, the annual rainfall is 34.59, of which amount 13.51 inches descend in spring, 1.18 in summer, 4.87 in the autumn, and 15.03 in the winter. Southward the same phenomenon occurs in this country at Fort Reading, Sacramento, Benicia, San Francisco, Fort Miller, Monterey, and San Diego.

8. Along the shores of the Pacific, the annual amount of rain increases with the increase of latitude; for while the annual rainfall at San Francisco, 37° 48′ north latitude, is only 22.18 inches, that of Astoria, in 46° 11′ north latitude, is 53.49 inches. The results of the observations made in this region show that the rains which here occur are chiefly due to the prevalent higher winds, the reverse current of the trade, which, sweeping over the Pacific, comes loaded with moisture to the land. In the particulars just mentioned, the Atlantic coast differs from the Pacific; for the rainfall there decreases with the latitude, and the northeast winds bring rain.

9. As far as observations have been made, Southern Alaska appears to be a region of almost constant precipitation. The character of this region, both in respect to the amount of its humidity and its cause, has already been explained on a preceding page. The mean annual rainfall at Sitka has been found, from the observations of seven years, to be 89.94 inches.

10. **Climate.**—The climatic divisions of the United States are the same as those which obtain in respect to humidity, with the exception of the fourth, which embraces the interior and northern portions of Alaska, to the exclusion of the southern coast.

11. The first division, comprising the Atlantic Slope and the Great Central Plain, possesses a climate marked by oceanic and continental as well as temperate and tropical characteristics. The greatest precipitation of moisture is found along its coasts, the rainfall decreasing with the distance from the sea. It is distinguished for the most part by great extremes of temperature, low winter temperatures alternating with high summer heats. Thus, at Salem in Massachusetts the mean temperature of summer is 70°.1 Fah., while that of winter is 27°.9 Fah.; and at St. Louis, Missouri, the summer mean is 76°.3 Fah. and the winter 33°.8 Fah. At New Orleans the mean of the summer rises as high as 82°.3 Fah., yet in the winter snow-storms sometimes occur. This region is also remarkable for its sudden changes in temperature: at Hartford, Connecticut, during the month of February, 1861, the thermometer sank *sixty* degrees in the course of *sixteen* hours. These extreme thermal changes are connected with much variation in respect to humidity, periods of great moisture being sometimes followed by severe droughts: yet the rains, as we have seen, fall abundantly throughout this region.

12. The climate of the Rocky Mountain zone, as far as it has been ascertained, appears to be uniform, on the whole, but to possess much variety in different parts. It is continental in its character, and resembles that of the plateaus of Central Asia. The air in this region is dry and rarefied, and so arid is the soil that its finer particles are driven by the winds, like snow, into drifts which are often several feet deep. The annual temperature, though lower than in the corresponding latitudes in the east and west, does not sink so much as might be expected from the great altitude of this district. The diurnal changes of temperature are exceedingly great, the thermometer being sometimes below the freezing point at sunrise, and rising to 80° Fah. in the hottest part of the same day.

13. The Pacific Slope possesses a climate similar, for the most part, to that of Western Europe. Although subject in different localities to great and sudden variations, it is, on the whole, more uniform than the climate of the Atlantic coast, the summer being comparatively cool, and the winter warm and equable. These peculiar climatic features are attributed to the combined influence of the heated regions of the interior, and the presence of masses of cold water off the coast and which appear to flow down from the Arctic Seas. Unlike the atmosphere of the eastern shores, that of the Pacific coast is dry and invigorating as far north as the Columbia River, beyond which point the humidity becomes excessive. From Oregon to the peninsula of Alaska the climate is singularly genial for such high latitudes. This mildness of temperature is caused by the Japan Current, the Gulf Stream of the Pacific, which carries the warm waters of the equator by the side of the eastern coast of Asia and across the ocean to America, and thence southward along its shores back to the equator. Sitka is said to be as warm in winter as Washington, and its average yearly temperature is very nearly the same as that of Kinderhook in New York. In the southern part of the Pacific slope, so extraordinary are the prolific influences of the soil and climate, that the grasses, trees, fruits, and grains attain a most remarkable development.

14. In the northern and interior regions of Alaska the climate is one of Arctic rigor. At St. Michaels, which is situated in 63° 28′ north latitude, the mean yearly temperature is about 26° Fah. During the month of July in 1867, a thunderstorm occurred here,—a phenomenon which had not happened before for the space of thirteen years. At Fort Youkon, in 67° north latitude, the annual mean temperature is only 16°.92 Fah.

15. **Natural Products.—Agricultural.**—The staple agricultural products of the United States are the cereals, cotton, tobacco, sugar, rice, potatoes, and hay. Of the cereals, Indian corn and wheat are the most important crops. The former flourishes from the plains of Texas to the Red River basin, where it grows and ripens in the parallel of 50° north latitude; the latter has an extensive range of growth, but the great wheat-regions occur in the central part of the Mississippi Valley. Wheat is also very extensively raised in California. The wheat crop of the present year (1867), according to the returns to the Department of Agriculture, is 225,000,000 bushels.

Cotton is the growth of the Southern States, and constitutes their most important staple: the amount of cotton raised in 1860 was upwards of 5,000,000 bales of 400 pounds each.

Tobacco, though chiefly produced in the southern portion of the country, is extensively cultivated throughout most of the States. A very fine quality of tobacco is raised in the Connecticut Valley.

Rice is largely produced in most of the Southern States, and the sugar-cane is successfully cultivated in Louisiana: it is said to have matured as far north as Holly Springs, in Mississippi, near the parallel of 35°.

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7. Describe the distribution of rain on the Pacific Slope. 8. Compare the Atlantic and Pacific coasts in regard to humidity. 9. What is said of Southern Alaska? 10. What are the climatic divisions of the United States? 11. Describe the first. 12, 13, Describe the climate of the Rocky Mountain zone, and that of the Pacific coast. 14. What is the climate of the northern and interior regions of Alaska? 15. What are the principal agricultural products of the United States? Give an account of each. State the amount of the respective crops for the year 1866.

According to the Banker's Magazine, of New York, the aggregrate of crops for 1866 is as follows:—

Wheat	151,999,906 bushels.	Buckwheat	22,791,830 bushels.
Indian Corn	867,946,295 "	Potatoes	107,200,976 "
Rye	26,864,944 "	Tobacco	388,128,684 pounds.
Oats	268,141,077 "	Hay	21,778,627 tons.
Barley	11,238,078 "		

16. **Mineral and Metallic.**—New England, and especially New Hampshire, abounds in granite, which is extensively employed for building purposes; and immense deposits of sandstone, of an excellent quality, occur throughout the Connecticut Valley and many other regions. Marble is very widely distributed, being found in New England, the Middle, Southern, and Western States, and also in California. The white marble of Vermont is of a very superior quality. Variegated and clouded marbles also here occur, and likewise in Pennsylvania, Maryland, Tennessee, and California. The marbles of Tennessee and California are extremely beautiful. Limestone abounds in the Mississippi Valley.

Scarcely any precious stones have been found within the United States. A single diamond has been discovered in North Carolina, and some of these gems are reported to have been found in California. Topaz occurs at Monroe, in Connecticut, chalcedony in many localities, and carnelians and agates are found abundantly along the shores of Lake Superior and on the banks of the Upper Mississippi.

The coal of the United States consists of two kinds, namely, *anthracite* and *bituminous*, and in no other country on the globe is it found in such immense deposits. The coal-fields comprise mainly four principal regions. The *first*, or great Appalachian coal-field, extends from Pennsylvania to near Tuscaloosa, Alabama, and covers a surface of seventy thousand square miles, including the bed of anthracite coal in Eastern Pennsylvania, which has an area of seven thousand square miles. The *second*, fifteen thousand square miles in extent, is in Central Michigan. The *third* stretches northward from Kentucky, through Indiana and Illinois, to Rock River, and has an area of fifty thousand square miles. The *fourth* begins on the south, near Red River, in Arkansas, and terminates northward in Iowa, having an area of fifty-seven thousand square miles. Coal-beds also exist on the Pacific Slope and in other regions.

Vast quantities of salt cover the saline plains of the Great Interior Basin, but the salt of commerce in the United States is derived from saline springs. Among the most productive of these are the salt springs of Syracuse, in New York, and those of Pennsylvania and Virginia. Salt springs occur in many localities, being found in Kentucky, Ohio, Utah, Colorado, New Mexico, and other parts of the country.

17. The United States is rich both in the useful and the precious metals. Iron is very widely diffused throughout the country. Valuable ores are found in the Northern States, and abundant and extensive beds occur in New York and Pennsylvania; and this metal is also found in various parts of the Rocky Mountain zone. But the immense deposits of Missouri exceed all others, both in their extent and purity, the iron forming whole mountains, as in the case of Pilot Knob and in that of the Iron Mountain.

The copper region of Lake Superior probably surpasses in richness all others in the world. The metal is here found in a pure state, and in immense masses. A single sheet of copper was discovered in the Minnesota Mine, which was computed to weigh at least two hundred and fifty tons. Copper is also found in Tennessee, Michigan, California, and numerous other regions. It is very abundant in the latter State, which is said now to export yearly 10,000 tons of this metal.

Immense deposits of lead occur in Missouri, Illinois, Iowa, and Wisconsin. It is also found in New York, Pennsylvania, Virginia, Oregon, and in many regions besides. Zinc occurs in New Jersey, Pennsylvania, Tennessee, Missouri, and other localities.

Arsenic, cobalt, and antimony are found in Connecticut. Several quicksilver-mines of exceeding richness have been discovered in the Santa Clara Valley in California, which is the only region in the United States where this metal has hitherto been found. In 1866, more than half the whole production of the quicksilver-mines of the globe came from California.

Silver occurs in small quantities in some of the Eastern States, and is also associated with the copper of the Lake Superior districts. But this precious metal is widely distributed throughout the great Western mountain-zone, being found, among other regions, in New Mexico, Arizona, California, Nevada, and Oregon.

Gold occurs at intervals in a metalliferous belt which extends from Northern New England to Georgia, the southern portion being the most productive. In North Carolina the gold-fields extend over an area of one hundred square miles. But the most abundant deposits by far are found in the Rocky Mountain zone and the Pacific Slope; valuable mines having been discovered in Nevada, Colorado, New Mexico, Idaho, Oregon, and other localities, while the renowned gold-fields of California are the richest in the world. Gold was first discovered in this State in 1848, and its mines have produced within the space of eleven years, ending with 1866, no less than 1327 tons of gold, of the value of eight hundred millions of dollars.

18. **Physical Advantages.**—The physical advantages of the United States are great and varied. Alike removed, with the exception of Alaska, from the scorching heat of the torrid zone and the rigors of a polar clime, their well-watered plains and slopes, outspread beneath a favoring sky, teem with the rich and numerous products of the soil. Noble rivers, piercing into the heart of the continent, bear upon their waters the commodities of foreign lands, afford immense facilities for internal navigation, and likewise abundant means by which native products may be extensively exported. But vast as are the resources of the United States, they are yet but partially developed: many a fertile region awaits the hardy pioneer, and the present rich yield of their mines seems to be scarcely more than an indication of the treasures that are yet to be revealed. Nor must the favorable position of this country on the globe be forgotten: situated with the Pacific on the west, and the Atlantic on the east, it bids fair, with its trans-continental railroads, and its merchant fleets on either ocean, to become the highroad of commerce between the rich provinces of Eastern Asia and the boundless enterprise and energies of the nations of Western Europe. No nation possesses a fairer domain than that of the American People.

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16. What is said of the distribution and extent of granite, sandstone, marble, and limestone? What respecting gems? Describe the coal and the coal-fields of the United States. What is said in regard to salt? 17. What is observed respecting the metals of this country? Give an account of each of the useful metals. State what is said in respect of the distribution and extent of the precious metals. 18. What are the physical advantages of the United States?

REVIEW AND MAP QUESTIONS ON THE PHYSICAL PHENOMENA OF THE UNITED STATES.

CHAPTER I.

EXTENT, COAST-LINE, INLETS, CAPES AND PENINSULAS, ISLANDS, GEOGRAPHICAL POSITION.

What is the extent of the territory of the United States?
Between what degrees of latitude and longitude does it lie?
What is said of the extent of the coast-lines?
What is the respective extent of the coast-line on the eastern, southern, and western shores?
What are the chief inlets?
Name the principal capes and peninsulas on the Atlantic coast, and designate them on the map.
Those on the Gulf of Mexico.
Those on the Pacific coast.
Those on the Arctic coast (see map of Alaska).
Mention the principal islands on the Atlantic coast, and designate them on the map.
On the Gulf coast.
On the Pacific coast, including the islands of Alaska
What is observed in respect to the geographical position of the United States?
How situated in regard to climate?

CHAPTER II.

NATURAL DIVISIONS, GEOLOGICAL CHARACTER, MOUNTAINS, AND MOUNTAIN-SLOPES.

Name in order the principal natural divisions of the United States.
State what is said concerning the geological features.
Within what great tracts are the older rocks included?
Describe the two divisions.
What is said of the more modern formations?
Point out on the map the Alleghany Mountain System.
The Rocky Mountain System.
The Pacific System, including the Coast, Cascade, and Sierra Nevada.
Describe the northeastern and also the southwestern group of the Alleghany Mountains.
Of what is the Rocky Mountain System a part?
Describe it in full.
What is said concerning the Pacific System?
What are the chief mountain-slopes of the United States?
Describe them.

CHAPTER III.

TABLE-LANDS, PLAINS, AND VOLCANOES.

Which are the principal table-lands of the United States?
Of what does the eastern plateau consist?
Describe the Staked Plain.
The western plateau, how divided?
Describe the Great Interior Basin.
Mention the two great plains of the United States.
Point out on the map and describe the Great Central Plain, or Valley of the Mississippi.
Describe the Atlantic Plain.
What is said of the volcanoes in the United States?
What mountains have been seen in a state of eruption?
What is remarked respecting the volcanoes of the Aleutian Isles?

CHAPTER IV.

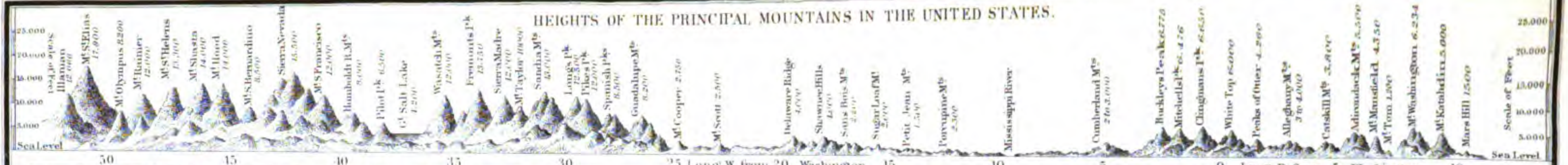
LAKES AND RIVERS.

Point out on the map the great lakes of the United States.
Describe Lake Superior and Lake Huron.
Describe Lake Michigan, Lake Erie, and Lake Ontario.
In what way do the great lakes afford facilities to commerce?
For what are Lakes Champlain and George noted?
Where do salt lakes occur?
Describe the Great Salt Lake, Lake Utah, and Lake Majesty.
Name the seven systems under which the rivers of the United States are comprised, and point out the position of each on the map.
Give a description of the Hudson Bay System.
What are the principal rivers of the Atlantic System?
Of the Gulf System?
Mention what is said concerning the Mississippi River.
What rivers are included in the Pacific System?
Describe the Behring and Arctic Systems.
Trace on the map the course of the river Kwichpak.
Describe the Continental System.
Show its position on the chart.

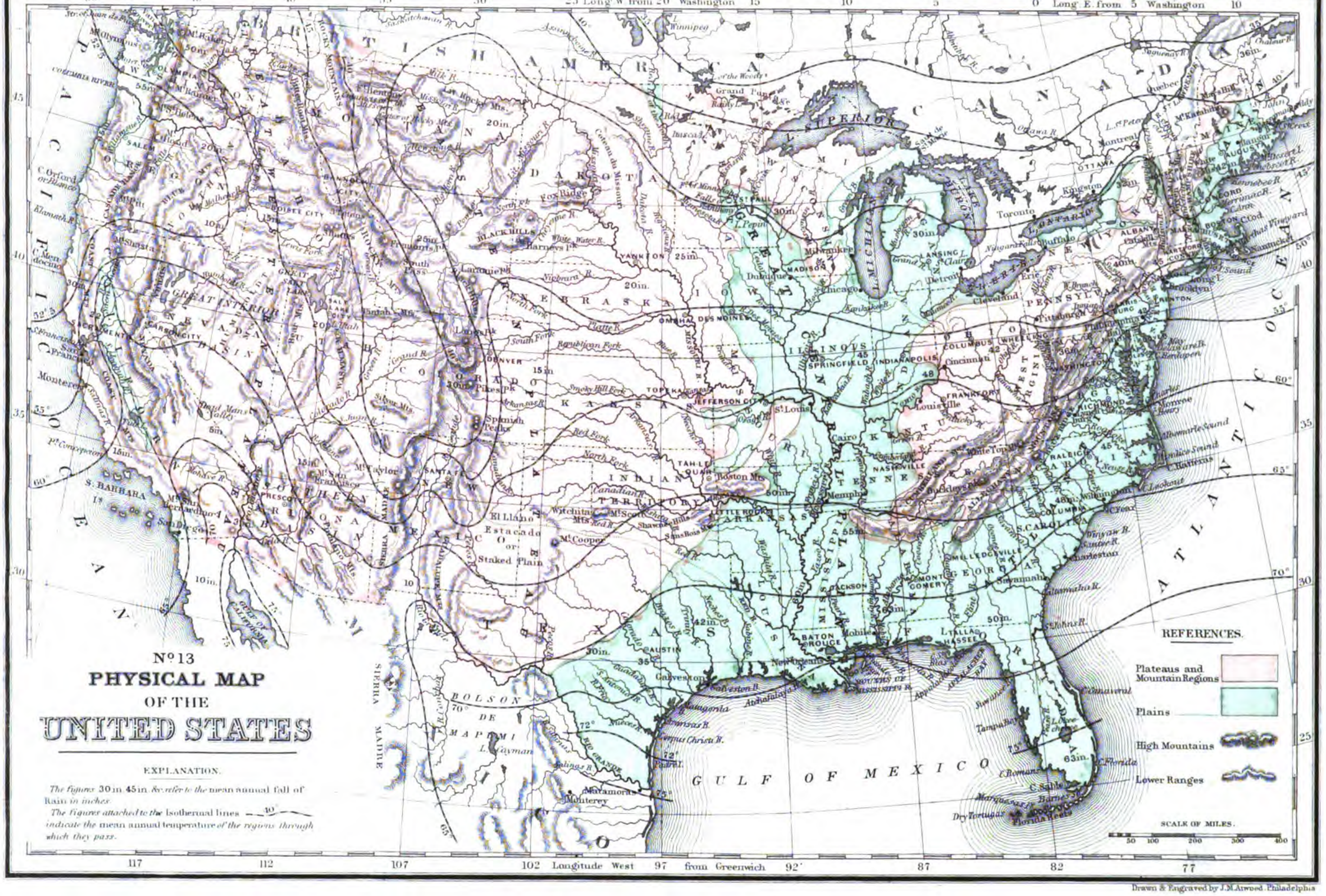
CHAPTER V.

METEOROLOGICAL PHENOMENA, CLIMATE, AND NATURAL PRODUCTIONS.

State what is said of the temperature of the United States.
Give the highest and lowest mean temperatures.
State what is said of the departures of the isothermals from the parallels of latitude.
Trace these departures on the map.
State what is said of winds.
What is said of winds on the Gulf of Mexico?
What of northwesterly winds?
What is said of tornadoes?
How are the United States classed as respects the quantity and distribution of rain?
Describe the rainfall in the Atlantic Slope and Great Central Plain.
In the Rocky Mountain district.
In the Pacific Slope.
Along the shores of the Pacific.
In Southern Alaska.
Name the several climatic regions, point them out on the map, and describe each of them.
What are the staple agricultural products of the United States?
What is said of the extent of the wheat crop of 1867?
What of the cotton crop of 1860?
Where is tobacco cultivated?
Where are granite, sandstone, and marble found?
What is said of precious stones?
Describe the coal-fields of the United States.
What is remarked respecting salt?
What is said as to the richness of the United States in metals?
Give an account of iron, copper, lead, quicksilver, silver, and gold.
Which is the richest gold-field in the United States?



HEIGHTS OF THE PRINCIPAL MOUNTAINS IN THE UNITED STATES.



N^o 13

PHYSICAL MAP
OF THE
UNITED STATES

EXPLANATION.

The figures 30 in. 45 in. *&c. refer to the* mean annual fall of Rain *in inches.*

The figures attached to the Isothermal lines *indicate the* mean annual temperature *of the regions through which they pass.*

REFERENCES.

Plateaus and Mountain Regions	▭
Plains	🟩
High Mountains	
Lower Ranges	

Drawn & Engraved by J.M.Atwood. Philadelphia

HEIGHTS OF THE PRINCIPAL MOUNTAINS, PEAKS, AND VOLCANOES IN THE WORLD.

Name.	*Height, in feet.*	*Range.*	*Country.*
NORTH AMERICA.			
Mount St. Elias, *V.*	17,900	Pacific Coast	Alaska.
Popocatepetl, *V.*	17,720	Sierra Madre	Mexico.
Mount Brown	16,000	Rocky	British America.
Mount Hooker	15,700	Rocky	British America.
Sierra Nevada	15,500		California.
Iztaccihuatl, *V.*	15,300	Sierra Madre	Mexico.
Mount Fairweather	14,700	Pacific Coast	Alaska.
Mount Hood, *V.*	14,000	Cascade	Oregon.
Mount Shasta	14,000	Cascade	California.
Frémont's Peak	13,750	Rocky	Idaho.
Mount St. Helens, *V.*	13,300	Cascade	Washington.
Long's Peak	12,500	Rocky	Colorado.
Iliaman, *V.*	12,066	Pacific Coast	Alaska.
Wrangell, *V.*	12,064	Pacific Coast	Alaska.
Pike's Peak	12,000	Rocky	Colorado.
Mount Rainier	12,000	Cascade	Washington.
Sierra Madre	12,000		Mexico.
Cibao Mountains	8,600	Haytian Range	Hayti.
Blue Mountains	8,184	Cold Ridge	Jamaica.
Sierra del Cobre	7,200		Cuba.
Mount Bulkley	6,775	Alleghany	North Carolina.
Mount Mitchell	6,476	Alleghany	North Carolina.
Mount Washington	6,234	White	New Hampshire.
Mount Marcy	5,500	Adirondack	New York.
Jorullo, *V.*	4,265		Mexico.
Izalco, *V.*	4,000		Mexico.
SOUTH AMERICA.			
Aconcagua, *V.*	23,100	Andes	Chili.
Tupungato, *V.*	22,016	Andes	Chili.
Gualateiri	22,000	Andes	Peru.
Chimborazo, *V.*	21,420	Andes	Ecuador.
Sorata, *V.*	21,286	Andes	Bolivia.
Illimani	21,140	Andes	Bolivia.
Arequipa, *V.*	20,320	Andes	Peru.
Cayambe, *V.*	19,333	Andes	Ecuador.
Cotopaxi, *V.*	19,000	Andes	Peru.
St. Martha	19,000	Northern Coast	U. S. of Colombia.
Tolima	18,200	Andes	U. S. of Colombia.
Maypu, *V.*	17,664	Andes	Chili.
El Altar, *V.*	17,457	Andes	Chili.
Potosi	16,150	Andes	Bolivia.
Sangay, *V.*	16,138	Andes	Peru.
Pichincha, *V.*	15,922	Andes	Peru.
Juruoco	8,400	Brazilian Coast	Brazil.
Roraima	7,150	Parime	Venezuela.
Itambe	5,960	Brazilian Coast	Brazil.
Itacolumi	5,700	Brazilian Coast	Brazil.
EUROPE.			
Elburus	17,776	Caucasus	Russia.
Mont Blanc	15,668	Alps	France.
Monte Rosa	15,223	Alps	Italy.
Mount Mulahacen	11,668	Pyrenees	Spain.
Mount Maladetta	11,468	Sierra Nevada	Spain.
Mount Etna, *V.*	10,874		Sicily.
Mount Cavallo	10,154	Apennines	Italy.
Mount Scardus	10,000	Balkan	Turkey.
Mount Ruska Poyana	9,912	Carpathian	Austria.
Mount Olympus	9,749	Pindus	Turkey.
Mount Hæmus	8,874	Balkan	Turkey.
Mount Rotondo	8,767		Corsica.
Mount Sneehätten	8,000	Kiölen	Norway.
Mount Tatra	7,000	Carpathian	Austria.
Mount Koujaskofski-Kamen	5,397	Ural	Russia.
Ben Cruachan	5,000		Scotland.
Vesuvius, *V.*	3,947		Italy.
Mount Snowdon	3,571		Wales.
Grampian Hills	3,500		Scotland.
Carran Tual	3,400		Ireland.
Sca Fell	3,166		England.
Stromboli, *V.*	2,687		Lipari Isles.
ASIA.			
Mount Everest	29,100	Himalaya	India.
Kunchinjunga	28,157	Himalaya	India.
Karakorum	27,820	Himalaya	India.
Nanda Dewi	24,000	Himalaya	India.
Koosh Peak	20,000	Hindoo Koosh	Afghanistan.
Kuen Lun Peak	20,000	Kuen Lun	Thibet.
Ararat	17,210	Taurus	Turkey.
Demavend Peak	14,660	Elborz	Persia.
Mount Olympus	13,000	Taurus	Turkey.
Jebel-Makmel Peak	12,182	Lebanon	Syria.
Byelucha	11,000	Altai	Siberia.
Kentei Khan	11,000	Tangnou	Siberia.
Hochow, *V.*		Thian Shan	Soongaria.
Peshan, *V.*		Thian Shan	Soongaria.
Mount Hermon	10,000	Asia Minor.	Palestine.
Dodabetta	8,760	Ghauts	Hindoostan.
Wiljuish Mount	8,000		Siberia.
Mount Sinai	7,496		Arabia.
AFRICA.			
Kilimanjaro	20,000	Mountains of the Moon	West Coast.
Kenia	20,000	Mountains of the Moon	West Coast.
Rus Detschen Peak	15,986		Abyssinia.
Cameroons	14,000	Guinea System	Lower Guinea.
Jebel Tedla	13,000	Atlas	Morocco.
Madagascar System	12,000		Madagascar Island.
Peak of Teneriffe, *V.*	12,000		Island Teneriffe.
Mount Miltain	11,400	Atlas	Morocco.
Snow Mountains	10,000	Cape System	Cape Colony.
Peak of Pico	7,613		Island Azores.
Kong	3,000		Soudan.
OCEANICA.			
New Guinea Range	16,000		New Guinea.
Singalang, *V.*	15,000		Sumatra.
Mauna Loa, *V.*	13,760		Sandwich Islands.
Semero Mount	13,000		Java.
Mount Cook	12,200		New Zealand.
Sumbou, *V.*	11,028		Java.
Mount Otaheite	10,250		Georgian Isles.
Tomboro, *V.*	7,600		Sumbawa I.
Mount Kosciusko	6,500		Australia.
Mount Humboldt	5,520		Tasmania.
Mount Kilauea, *V.*	4,000		Hawaii.

THE PRINCIPAL RIVERS OF THE WORLD, THEIR SYSTEMS, LENGTHS, AREA OF BASIN, AND MOUTHS.

River.	*Length.*	*Area of Basin.*	*Mouth.*
ARCTIC SYSTEM.			
Mackenzie	2,600	441,600	Arctic Ocean.
Great Fish	900		Arctic Ocean.
Coppermine	250		Arctic Ocean.
Obe	2,500	924,800	Gulf of Obe.
Yenisei	2,300	784,000	Yenisei Gulf.
Lena	2,600	594,000	Arctic Ocean.
Kolima	930	143,000	Arctic Ocean.
Dwina	1,000	142,000	White Sea.
Petchora	700	65,000	Petchora Gulf.
Onega	250		White Sea.
ATLANTIC SYSTEM.			
Saskatchawan and Nelson	1,600	360,000	Hudson Bay.
Churchill	974	74,000	Hudson Bay.
St. Lawrence	2,200	297,600	Gulf of St. Lawrence,
Susquehanna	630		Chesapeake Bay.
Mississippi	4,100	982,400	Gulf of Mexico.
Rio Grande	1,800	180,000	Gulf of Mexico.
Magdalena	828	72,000	Caribbean Sea.
Orinoco	1,500	297,000	Atlantic Ocean.
Amazon	3,600	1,512,000	Atlantic Ocean.
Para and Tocantins	1,300	388,000	Atlantic Ocean.
San Francisco	1,550	187,200	Atlantic Ocean.
La Plata	2,250	886,400	Atlantic Ocean.
Vistula	520	56,640	Gulf of Dantzic.
Oder	480	39,040	Baltic Sea.
Elbe	684	41,860	North Sea.
Weser	250	13,100	North Sea.
Rhine	600	65,280	North Sea.
Thames	215	65,000	North Sea.
Seine	497	22,620	English Channel.
Loire	520	33,940	Bay of Biscay.
Tagus	540	40,000	Atlantic Ocean.
Ebro	420	25,000	Mediterranean Sea.
Rhone	650	33,000	Mediterranean Sea.
Danube	1,600	234,080	Black Sea.
Dnieper	1,080	169,680	Black Sea.
Don	960	168,420	Sea of Azof.
Nile	3,600	520,200	Mediterranean Sea.
Senegal	1,200		Atlantic Ocean.
Niger	2,600	600,000	Gulf of Guinea.
Congo	1,000		Atlantic Ocean.
PACIFIC SYSTEM.			
Kwichpak	2,500		Norton Sound.
Columbia	1,200	194,000	Pacific Ocean.
Colorado	1,100	170,000	Gulf of California.
Amoor	2,200	582,800	Sea of Ochotsk.
Hoang-Ho	2,500	537,400	Eastern Sea.
Yang-tse-Kiang	3,000	547,800	Eastern Sea.
Cambodia	2,000	216,000	China Sea.
INDIAN SYSTEM.			
Euphrates	1,400	unitedly }	Persian Gulf.
Tigris	1,150	195,000 }	Euphrates.
Indus	1,700	312,000	Arabian Sea.
Ganges	1,600	unitedly }	Bay of Bengal.
Brahmaputra	1,500	432,480 }	Bay of Bengal.
Irrawaddy	1,700	331,200	Bay of Bengal.
Zambezi	1,000	432,000	Mozambique Channel.
Murray			Indian Ocean.
CONTINENTAL SYSTEMS.			
Humboldt	350		Humboldt L., Nevada.
Volga	2,000	397,400	Caspian Sea.
Ural	1,000	53,200	Caspian Sea.
Sihon	900	unitedly }	Aral Sea.
Amoo	800	431,900 }	Aral Sea.

ELEVATION OF SOME OF THE IMPORTANT PLATEAUS OR TABLE-LANDS OF THE WORLD.

NORTH AMERICA.	
Eastern Plateau of the Rocky Mountains	2,000 to 6,000
From the Pecos to the Forks of the Nebraska	4,000
El Llano Estacado	2,500 to 3,500
Great Western Plateau.	
Great Interior Basin	4,000 to 5,000
Northern Plateau	3,000 to 4,000
Southern Basin	3,000 to 7,567
Mexican Plateaus.	
Plateau of Toluca	8,570
Plateau of Anahuac	6,000 to 8,000
Plateau of Tenochtitlan	7,470
Plateau of Aclopan	6,450
Plateau of Istla	3,320
Central America.	
Plateau of Guatemala	5,000
Plateau of Costa Rica	5,000
SOUTH AMERICA.	
Plateau of Colombia	8,700
Plateau of Popayan	5,760
Plateau of Ecuador	10,000
Plateau of Peru and Bolivia	12,000
Plateau of Brazil	3,200
EUROPE.	
Plateau of the Spanish Peninsula	2,000 to 3,000
Plateau of Auvergne, France	1,087
Plateau of Bavaria	1,663
ASIA.	
Plateau of Asia Minor and Armenia	2,800 to 3,280
Plateau between the Black and Caspian Sea	7,000
Plateau of Arabia	5,000 to 8,000
Plateau of Persia	2,000 to 3,500
Plateau of Central Asia (Western Part)	3,000
Plateau of Cobi	2,400 to 6,000
Plateau of Thibet	12,000 to 17,000
Plateau of Deccan	1,500 to 2,000
Plateau of Mysore	4,000 to 5,000
AFRICA.	
Abyssinian Plateau	7,000 to 8,000
South African Plateau	2,400 to 5,000

AREA, ELEVATION, AND DEPTH OF SOME OF THE PRINCIPAL LAKES IN THE WORLD.

	Area, square miles.	Elevation above the sea, feet.	Depth, feet.
Caspian Sea	145,000	} 80 below.	very deep
Aral Sea	30,000	}	not deep
Lake Superior	31,500	627 above	900
Lake Michigan	23,150	595 do.	900
Lake Huron	23,100	555 do.	1,800
Lake Baikal	14,000	1,800 do.	over 500
Lake Erie	7,800	500 do.	270
Lake Ontario	6,900	200 do.	500
Lake Winnipeg	9,000	628 do.	
Lake Ladoga	6,190		
Lake Nicaragua	3,500	130 do.	
Lake Titicaca	4,000	12,847 do.	
Great Salt Lake	1,875	4,200 do.	
Lake Nemi			2,709
Dead Sea	320	1,298 below	700
Sir-i-Kol		15,600 above	
Chapala, Mexico	1,000	7,000 do.	
Lake Wuler, India	45	5,500 do.	
Victoria Nyanza		3,308 do.	
Albert Nyanza		2,720 do.	

PRINCIPAL PLAINS OF THE WORLD.

NORTH AMERICA.

Great Central Plain of North America.
Atlantic Plain.

SOUTH AMERICA.

Llanos of the Orinoco.
Silvas of the Amazon.
Pampas of South America.
Pacific Plain.

EUROPE.

Great Northern Plain of Europe.
Southern Plain of Europe.

ASIA.

Siberian Steppes and Plain.
Lowlands of China.
Plains of Farther India.
Plain of Hindoostan.
Lowland of Turan.
Lowlands of Syria.

AFRICA.

The Sahara. The Central Plain of Africa.

PRONOUNCING VOCABULARY.

In this Vocabulary, ah represents the sound of *a* in far; ay, that of *a* in fate; ă, *a* in fat; aw, *aw* in law; ĕ, *e* in met; ĕĕ, *i* in fit; eh, *e* in berth; ī, *i* in pine; ĭ, *i* in pin; ō, *o* in mode; ŏ, *o* in not; oo, *oo* in moon; ŏŏ, *oo* in wood; ōw, *ow* in throw; ŏw, *ow* in now; ū, *u* in pure; ŭ, *u* in run; gh, *g* in get; ñ, *ny* in banyan; ɴ, *n* in won't; *th* (*italic*), *th* in then; th, *th* in thin; ʊ, prolonged sound of *u* in thus; ö, almost like *e* in her; ü, the French *u*, and German ü, a sound between that of ee and of oo; ɴɢ, the French nasal sound, somewhat like that of *ng* sounded through the nose. The last three sounds can be properly communicated only by an oral instructor.

A.

Abyssinia, ab-is-sin'e-ah.
Acaray, ah-kah-rī'.
Aclopan, ahk-lo-pahn'.
Aconcagua, ah-kon-kah'gwah.
Adansonia, ad-an-so'ne-ah.
Adelsberg, ah'dels-bĕrg.
Adelung, ah'deh-lŏŏng.
Adirondack, ad-e-ron'dak.
Aeronaut, ay'er-o-nawt.
Agassiz, ag'ă-see, *or* ă-gass'iz.
Aguachapa, ah-gwah-chah'pah.
Agulhas, ah-gool'yahs.
Air, ah-eer'.
Alascisci, ah-lah-sis'ke.
Ala Tagh, ah'lah tahg.
Albinos, ăl-bi'noze.
Aleutian, ah-loo'she-an.
Alleghany, ăl-le-gay'ne.
Almaden, ahl-mah-*th*en'.
Aloes, al'oze.
Altai, ahl-tī'.
Altamaha, awl-tah-mah-haw'.
Altyn Kool, ahl-tin' kool.
Aluminum, ă-loo'me-num.
Anahuac, ah-nah-wahk'.
Andaman, an-dă-man'.
Anemone, ă-nem'o-ne.
Anthelia, ant-heel'yah.
Antigua, ahn-te'gah.
Appalachian, ap-pă-lay'che-an.
Apteryx, ap'ter-iks.
Apure, ah-poo'ray.
Apurimac, ah-poo-re-mahk'.
Aqueous, ay'kwe-us.
Aquila, ah'kwe-lah.
Arabic, ăr'ă-bik.
Arago, ăr'ă-go.
Ararat, ăr'ă-rat.
Aras, ah-rahs'.
Aravulli, ar-ă-vul'le.
Archipelago, ar-ke-pel'ă-go.
Armadillo, ar-mă-dil'lo.
Artesian, ar-teez'yan.
Artois, ar-twah'.
Ascidian, as-sid'e-an.
Assam, ahs-sahm'.
Assyrians, as-sĭr'e-anz.
Astrakhan, ahs-trah-kahn'.
Astrapææ, as-tray'pe-e.
Atacama, ah-tah-kah'mah.
Atchafalaya, atch-ă-fă-lī'ah.
Athabasca, ath-ă-bas'kah.
Atoll, ă-tŏl'.
Audubon, aw'doo-bon.
Aurochs, aw'rocks.
Aurora Borealis, aw-ro'rah bo-re-ay'lis.
Auvergne, ō-vairñ'.
Avalanche, av-ă-lansh'.

B.

Bache, baitch.
Bagnes, bañ.
Bahr As'sel.
Baikal, bī'kahl.
Bakou, bah-koo'.
Balcash, bahl-kahsh'.
Bald Yökul, bahlt yö'kul.
Bali, bah'le.
Banca, bang'kah.
Banian, ban'yan, *or* ban-yan'.
Baobab, bay'o-bab.
Baraba, bah-rah-bah'.
Basaltic, bă-sawl'tik.
Basques, basks.
Batrachians, bă-tray'ke-ans.
Bechuanas, bet-choo-ah'naz.
Belleisle, bel-lile'.
Beluga, be-loo'gah.
Ben' Cruachan, ben-kroo'ken.
Bengal, ben-gawl'.
Beni, bay-ne'.
Benzoin, ben-zoyn'.
Beryl, bĕr'il.
Betel, be't'l.
Bilin, be-leen'.
Bimana, bi-may'nah.
Bison, bi'son.
Blumenbach, bloo'men-bahk.
Bogota, bo-go-tah'.
Bolivia, bo-liv'e-ah.
Bonifacio, bo-ne-fah'cho.
Bonin-Sima, bo-neen-se'mah.
Bonpland, bŏɴɢ-plŏɴɢ'.
Bootan, boo-tahn'.
Bornou, bor-noo'.
Brahmaputra, brah-mah-poo'trah.
Brahminism, brah'min-izm.
Buddhism, bood'izm.
Buenos Ayres, bo'nos ay'riz.
Bueras, bway-rah'.
Burckhardt, burk'hart.
Bushire, boo-sheer'.

C.

Cabul, kah-bool'.
Cacao, kă-kay'o.
Calcareous, kăl-kay're-us.
Calcium, kăl'se-um.
Callao, kahl-lah'o, *or* kahl-yah'o.
Camellia Japonica, kă-mel'yah jă-pon'e-kah.
Campagna, kahm-pahn'yah.
Canaveral, kă-nav'er-al.
Cañon, kahn-yōwn'.
Cantabrian, kan-tay'bre-an.
Caoutchouc, koo'chook.
Capellan, kah-pel-lahn'.
Capsicum, kap'se-kum.
Caraccas, kă-rak'kas.
Caribs, kăr'ibz.
Carnivora, kar-niv'o-rah.
Carran Tual, kar'ran too'al.
Carthago, kar-tah'go.
Casiquiare, kah-se-ke-ah'ray.
Cassava, kas'să-vah.
Cassowary, kas'so-way-re.
Caucasian, kaw-kay'she-an.
Caucasus, kaw'kă-sus.
Caxamarca, kah-hah-mar'kah.
Centrifugal, sen-trif'yoo-gal.
Cetacea, se-tay'she-ah.
Ceuta, soo'tah.
Cévennes, say-ven'.
Cevero Vostochnoi, say-vay'ro vos-tok'noy.
Chagos, chah'goce.
Chalcedony, kăl-sed'o-ne.
Chalybeate, kăl-lib'e-ate.
Chamois, shă-moy'.
Chamouni, shah-moo-ne'.
Chandeleur, shan-deh-loor'.
Chapala, chah-pah'lah.
Chapelle-aux-Planches, shah-pell'-ō-plŏɴsh'.
Charlemagne, shar-leh-mayn'.
Charybdis, kă-rib'diss.
Chasma, kasms.
Cheduba, che-doo'bah.
Cheiroptera, ki-rop'te-rah.
Chelonians, ke-lo'ne-ans.
Cheltenham, chelt'nŭm.
Cherokees, chĕr-ro-keez'.
Cherrapongi, chĕr-rah-pon-jee'.
Chignecto, shig-nek'to.
Chihuahua, che-wah'wah.
Chili, chil'le.
Chimborazo, chim-bo-rah'zo.
Chimpanzee, chim-pan'ze.
Chittagong, chit-tah-gong'.
Chladni, klahd'nee.
Chlorine, klo'rin.
Choco, cho'ko.
Chota, cho'tah.
Cibao, se-bah'o.
Cinchona, sin-ko'nah.
Circassians, sir-kash'yanz.
Cirrus, sĭr'rus.
Cleopatra, kle-o-pat'trah.
Cobra di Capello, ko'brah de kah-pel'lo.
Coca, ko'kah.
Cochineal, kotch'e-neel.
Cocoa-Palm, ko'ko-pahm'.
Com'orin.
Concepcion, kon-sep-se-ōwn'.
Conchas, kon'chas.
Copernicus, ko-per'ne-kus.
Copiapo, ko-pe-ah-po'.
Coringa, ko-ring'gah.
Corona, ko-ro'nah.
Costa Rica, kos'tah re'kah.
Cotidal, ko-tī'dal.
Cotopaxi, ko-to-pax'e.
Creuzot, krʊh-zō'.
Criba, kre'bah.
Crosthwaite, kross'thwait.
Cryptogamia, krip-to-gay'me-ah.
Cumana, koo-mah-nah'.
Cumulus, kū'mū-lŭs.
Cursores, kur-so'reez.
Cuvier, kü-ve-ay', *or* kü've-er.
Cuzco, koos'ko.
Cyclades, sik'lă-deez.
Cyclones, sī'klōnes.
Cyclopean, si-klo'pe-an.

D.

Dariel, dah-re-el'.
Daurian, dah-oo're-an.
Deccan, dek'kan.
Deinotherium, dī-no-the're-um.
Del Cane, del kah'nay.
Demavend, dem-ah-vend'.
Demerara, dem-er-ah'rah.
Desaguadero, dĕs-ah-gwah-*th*ay'ro.
De Saussure, deh-so-soor'.
Des Bois, day-bwah'.
Des Demoiselles, day dem-wah-zel'.
Despoblado, des-po-blah'do.
Dhole, dole.
Digitigrades, dij'it-e-graids.
Disa grandiflora, dī'sah gran-dī-flo'rah.
Djebel Shomer, jeb'el sho'mer.
Dnieper, ne'per.
Dniester, nees'ter.
Dolomieu, do-lo-me-yʊh'.
Dovrefield, do-vreh-fe-eld'.
Dranse, drahn'seh.
Dromedary, drum'e-der-e.
Drontheim, dront'hīme.
Dugong, doo-gong'.
Dumont d'Urville, dü-mŏɴɢ' door-veel'.
Dunsthohle, dŏŏnst'ho-leh.
Dureas, doo-ray-ah'.
Dwina, dwī'nah, *or* dwe'nah.

E.

Echinus, e-kī'nus.
Ecuador, ek-wah-dore'.
Edentata, e-den-tay'tah.
Ehrenberg, ay'ren-bĕrg.
El Altar, el ahl-tar'.
Elborz, el-borz'.
Elburus, el'boo-rooce.
El Gran Chaco, el grahn chah'ko.
Ellipsoid, el-lip'soyd.
El Llano Estacado, el l'yah'no es-tah-kah'do.
Emu, e'mew.
Endogens, en'do-jenz.
Entre Rios, en'tray re'oce.
Erebus, ĕr'e-bus.
Esquimaux, es'ke-mo.
Etesian, e-teez'yan.
Ethnol'ogy.
Euphrates, yoo-fray'teez.
European, yoo-ro-pe'an.
Everest, ev'er-est.
Exogens, ex'o-jenz.

F.

Fahrenheit, făr'en-hite.
Falkland, fawk'land.
Faroe, fay'ro, *or* fah'ro-eh.
Fata Morgana, fah'tah mor-gah'nah.
Fayal, fī-ahl'.
Fetichism, fet'e-shism.
Florida (Mexico), flo-re'*th*ah.
Florida (U.S.), flŏr'ī-dah.
Fluorine, floo'o-rin.
Fossiliferous, fos-sil-lif'e-rus.
Foucault, foo-ko'.
Foulahs, foo'laz.
Fournel, foor-nel'.
Frederickshall, fred'er-iks-hahl.
Fuegians, fu-e'jans.
Fungi, fun'ji.

G.

Gaelic, gay'lik.
Gailenreuth, ghī'len-roit.
Galapagos, gah-lah'pah-goce, *or* găl-lă-pay'gus.
Galeopithecus, găl-e-o-pī-the'-kus.
Gallas, gahl'lahz.
Galveston, găl'ves-tŭn.
Garonne, gah-ronn'.
Gay-Lussac, gay-lüs-sahk'.
Gennao, jen-nah'o.
Genoa, jen'o-ah.
Geral, zhay-rahl'.
Gesecke, gay-zek'eh.
Getroz, zheh-trōz'.
Geyser, ghī'ser.
Ghauts, gawtz.
Ghe'bers.
Gila, he'lah.
Gilolo, he-lo'lo.
Giraffe, je-raf'.
Glacier, glay'seer, *or* glas'e-er.
Gneiss, nice.
Golconda, gol-kon'dah.
Grallatores, gral-lă-to'reez.
Greenwich, grin'ij.
Grenelle, greh-nel'.
Grisons, gre-zōwɴɢ'.
Grudĕitz, groo-day'itz.
Guadeloupe, gaw-dă-loop'.
Gualateiri, gwah-lah-tay-e-re'.
Guanaco, gwah-nah'ko.
Guanaxuato, gwah-nah-hwah'to
Guardafui, gwahr-dah-fwee'.
Guatemala, gaw-te-mah'lah, *or* gwah-tay-mah'lah.
Guiana, ghe-ah'nah.
Gymnotus electricus, jim-no'tus e-lek'tre-kus.

H.

Hæmus, he'mus.
Halos, hay'loze.
Han-Hai, hahn-hī'.
Harmattan, har-mat'tan.
Hartz, harts.
Hasheesh, hash'eesh.
Hawaii, hah-wī'e.
Hayti, hay'te.
Hebrides, heb'rid-eez.
Herat, her-aht'.
Herault, ay-ro'.
Herbivorous, her-biv'o-rus.
Herschel, her'shel.
Hierapolis, hi-e-rap'o-lis.
Himalaya, him-awl'e-ah, *or* him-ah-lī'ah.
Hin'doo Koosh.
Hinter Rhin, hin'ter-rin.
Hippopotamus, hip-po-pot'ă-mus.
Hoang-Ho, ho-ang-ho'.
Hochow, ho-chŏw'.
Hogoleu, ho-go-lʊh'.
Holywell, hŏl'e-wel.
Honda, ōwn'dah.
Hoth'am.
Houssan, hŏw-sahn'.
Huancavelica, wahn-kah-vay-le'kah.
Huantajaya, wahn-tah-hī'ah.
Hungary, hung'gă-re.
Huzareh, huz'ah-reh.
Hyderabad, hi-der-ah-bahd'.
Hygrometer, hi-grom'ĕ-ter.

I.

Ichthyosaurus, ik-the-o-saw'rus.
Icononza, e-ko-non'zah.
Igneous, ig'ne-us.
Ignis-Fatuus, ig'nis fat'yoo-us.
Iguanodon, e-gwah'no-don.
Illimani, eel-ye-mah'ne.
Infusoria, in-fū-so're-ah.
Insectivora, in-sek-tiv'o-rah.
Insessores, in-ses-so'reez.
In-Shan, in-shahn'.
Ipecacuanha, ip-e-kak-yoo-an'ah
Irrawaddy, ĭr-rah-wod'de.
Irtysh, ĭr-tish'.
Ishim, ish-eem'.
Isothermal, ī-so-ther'mal.
Issi Kul, iss-e-kool'.
Istla, eest'lah.
Itabira, e-tah-be'rah.
Itacolumi, e-tah-ko-loo-me'.
Itambe, e-tahm'bay.
Itasca, ī-tas'kah.
Iztaccihuatl, ees-tahk-se-hwaht'l'.

J.

Jaguar, jag-yoo-ar'.
Jalapa, hah-lah'pah.
Jan Mayen, yahn-mī'en.
Jebel Tedla, jeb'el ted'lah.
Jorullo, ho-rool'yo.
Jungfrau, yŏŏnk'frŏw.
Juruoco, zhoo-roo-o'ko.

K.

Kabyles, kah'beelz.
Kaemtz, kemts.
Kalmucks, kăl'muks.
Kamtschatka, kahm-chaht'kah.
Kanawha, kă-naw'wah.
Karatau, kah-rah-taw'.
Kaseem, kah-seem'.
Katahdin, kă-tah'din.
Kenia, ke'ne-ah.
Kentei-Khan, ken-tay-kahn'.
Kerguelen, kerg'e-len, *or* kĕr-gay-loɴɢ'.
Khamsin, kam'sin.
Khinghan-Oula, king-gahn-oo'-lah.
Kianghan, ke-ahng-gahn'.
Kilauea, ke-lŏw-ay'ah.
Kilimanjaro, kil-e-mahn-jah-ro'.
Kiölen, ke-ö'len.
Kirguis, kĭr-gheez'.
Klamath, klahm'at.
Kodiak, ko'de-ak.
Konjaskofski-Kamen, kon-yah-skof'ske kah'men.
Kosciusko, kos-se-us'ko.
Kuen Lun, kwen-loon'.
Kuloch, koo'lok.
Kur, koor.
Kurdistan, koor-dis-tahn'.
Kurile, koo'ril.
Kuro Siwo, koo'ro-se'wo.
Kuttenberg, kut'ten-bĕrg.

L.

Laccadive, lahk'ă-dive.
La Chine, lah-sheen'.
Ladoga, lahd'o-gah.
La Merced, lah mĕr-sed'.
Langfield, lahnk-fe-eld'.
La Paz, lah-pahs'.

La Plata, lah-plah'tah.
Leeuwin, le'win.
Le Maire, leh-mair'.
Le'mur.
Lepidodendron, lep-e-do-den'dron.
Levant, le-vant'.
Lichens, li'kenz.
Lichtenstein, lik'ten-stine.
Lima, le'mah.
Linnæus, lin-ne'us.
Lipari, lip'ah-re.
Lithuania, lith-oo-ay'ne-ah.
Llaim-binn, l'yīm-bin'.
Llama, lah'mah.
Llanos, l'yah'noce.
Logodoen, log-o-do'en.
Loo-Choo'.
Loorgootha, loor-goo'thah.
Lupata, loo-pah'tah.
Luxan, loo-hahn'.

M.

Maca, mah-kah'.
Macao, mah-kŏw'.
Macquarie, mak-kwor're.
Madeira, mah-de'rah.
Maelstrom, mayl'strum.
Magellan, mah-jel'lan.
Magyars, mod-yorz'.
Mahableshwur, mah-hah-blesh-wur'.
Mahrattas, mah-rat'taz.
Malacca, mă-lak'kah.
Malachite, măl'ă-kite.
Maladetta, mah-lah-det'tah.
Malay, mă-lay'.
Maldive, mal'dive.
Malpais, mahl-pīce'.
Malte Brun, mawlt-brun', *or* mahl'teh-bruN'.
Malwa, mawl'wah.
Mammalia, mam-may'le-ah.
Mamore, mah-mo-ray'.
Manasarowar, mah-nah-sah-ro-wahr'.
Manatidæ, mă-nat'e-de.
Manco Capac, mahn'ko kah-pahk'.
Mandioc, man'de-ok.
Manganese, mang-gă-neez'.
Mantchooria, man-choo're-ah.
Maracaybo, mah-rah-kī'bo.
Maranham, mar-an-ham'.
Marmora, mar'mo-rah.
Marquesas, mar-kay'sahs.
Marsupialia, mar-soo-pe-ay'le-ah
Martinique, mar-tin-eek'.
Massuah, mahs'soo-ah.
Matagorda, mat-ă-gor'dah.
Maté, mah-tay'.
Matto Grosso, maht'to gros'so.
Mauna Loa, mŏw'nah lo'ah.
Mauritia, maw-rish'e-ah.
Mauritius, maw-rish'e-us.
Maypu, mī-poo'.
Medina, me-de'nah.
Megalosaurus, meg-ă-lo-saw'rus.
Megatherium, meg-ă-the're-um.
Meinam, may-e-nahm'.
Mendocino, men-do-se'no.
Mer de Glace, mair-deh-glahss'.
Mesopotamia, mes-o-po-tay'me-ah.
Metamorphic, met-ă-mor'fik.
Meteorite, me'te-o-rite.
Meteorology, me-te-o-rol'o-je.
Meyen, mī'en.
Michigan, mish'e-gan.
Mikra Kameni, mik'rah kah-may'ne.
Minnehaha, min-ne-hah'hah.
Mirage, me-rahzh'.
Mistral, mees'trawl.
Mocambe, mo-kahm'bay.
Mol'lusk.
Mongol, mon'gol.
Mongolian, mon-go'le-an.
Monotremata, mon-o-trem'ă-tah.
Monsoon, mon-soon'.
Mont Blanc, mŏNG-blŏNG'.
Monte Furca, mon'tay foor'kah.
Monterey, mon-tay-ray'.
Monte Rosa, mon'tay ro'sah.
Monte Rotondo, mon'tay ro-ton'do.
Moraines, mo-raynz'.
Moskoë, mos'ko-eh.
Mosyoatunyo, mos-yo-ah-toon'yo.
Moujgur, moodj-gur'.
Moussim, moo'sim.
Mozambique, mo-zam-beek'.
Mulahacen, moo-lah-ah-then'.
Müller, mĕĕl'er.
Mylodon, mil'o-don.
Mysore, mi-sore'.

N.

Nahr el Leben, nar-el-lay-ben'.
Nanda Dewi, nahn'dah day've.
Naphtha, naf'thah.
Narwhal, nar'wal.
Natatores, nay-tă-to'reez.
Nea Kameni, nay'ah kah-may'ne.
Nebêr el Fûar, nay-bĕr' el foo-ar'.
Nedsjed, ned'jed.
Neilgherries, neel-ghĕr'reez.
Nemi, nay'me.
Nepaul, ne-pawl'.
Nevada de Huila, nay-vah'dah day we'lah.
Nicaragua, nik-ah-rah'gwah.
Nicobar, nik'o-bar.
Nicot, ne-ko'.
Niemen, ne'men.
Niger, ni'jer.
Niti, nee'te.
Nitrogen, ni'tro-jen.
Notre Dame, nŏt'r-dahm'.
Nueces, nway'sĕs.
Nummulites, num'mû-lites.
Nummulitic, num-mû-lit'ik.
Nunnivack, noo-ne-vahk'.
Nyanza, n'yahn'zah.
Nyassi, n'yahs'se.
Nyöe, nü'o-eh.

O.

Oases, o'ă-seez, *or* o-ay'seez.
Oaxaca, wah-hah'kah.
Oberstein, o'ber-stine.
Obi, o'be.
Obsidian, ob-sid'e-an.
Ochotsk, o-kotsk'.
Ogeechee, o-ghe'che.
Ohlsen, ole'sen.
Olafsen, o'lahf-sen.
Olosenga, o-lo-seng'gah.
Oneida, o-nī'dah.
Oolites, o'o-lites.
Ophidians, o-fid'e-ans.
Oppido, op'pe-do.
Orchids, or'kidz.
Orchilla, or-kil'lah.
O'Shaughnessy, o-shaw'nes-se.
Osteolopis, os-te-o-lo'pis.
Ostia, os'te-ah.

P.

Pacaraima, pah-kah-rī'mah.
Pachydermata, pak-e-der'mă-tah
Paderborn, pah'der-born.
Padre, pah'dray.
Palaia Kameni, pah-lay'ah kah-may'ne.
Palatinate, pă-lat'e-nate.
Palgrave, pawl'grave.
Pallah, păl'lah.
Pamir, pah-meer'.
Pamlico, pam'le-ko.
Pamperos, pahm-pay'roce.
Panama, pahn-ah-mah'.
Pandanus, pan-dan'us.
Pantellaria, pahn-tel-lah-re'ah.
Papua, pap'oo-ah.
Paramaribo, par-ă-măr'e-bo.
Parana, pah-rah-nah'.
Paraselenæ, păr-ă-se-le'ne.
Parhelia, par-heel'yah.
Parime, pah-re'may.
Paros, pay'ros, *or* pah'ros.
Passamaquoddy, pás-să-mă-kwod'de.
Pecos, pay'koce.
Pedratallagalla, ped'rah-tahl-lah-gahl'lah.
Pele, pay'lay.
Penrhyn, pen'rin.
Pentelicus, pen-tel'e-kus.
Peshan, pay-shahn'.
Phanerogamia, fan-er-o-gay'me-ah.
Phosphorus, fos'fo-rus.
Pilares, pe-lah'rĕs.
Pisces Bartimei, pis'seez bar-tī-me'i.
Plantigrades, plan'te-graids.
Plateau, plah-to'.
Platinum, plat'e-num.
Platypus, plat'e-pus.
Plesiosaurus, ple-se-o-saw'rus.
Poeppig, pep-pig.
Polistina, po-lis-te'nah.
Polynesia, pol-e-ne'she-ah.
Polyps, pol'ips.
Pompeii, pom-pay'ee.
Popayan, po-pī-ahn'.
Popocatepetl, po-po-kah-tay-pet'l'.
Porphyritic, por-fe-rit'ik.
Porphyry, por'fe-re.
Potosi, po-to-se'.
Pouillet, poo-yay'.
Prairies, pray'reez.
Pro'teus.
Protococcus Nivalis, pro-to-kok'kus nī-vay'lis.
Prypet, prip'et.
Pterodactyl, tĕr-o-dak'til.
Puebla, pweb'lah.
Puget, pû'jet.
Pumachanche, poo-mah-chahn'chay.
Pumice, pum'iss.
Puna, poo'nah.
Punjaub, pun-jawb'.
Purace, poo-rah-say'.
Puszta, pooss'tŏh.
Puzzuoli, poot-soo-o'le.
Pyrenees, pīr'en-eez.
Pyrmont, peer'mont.
Pythagoras, pī-thag'o-ras.

Q.

Quadrumana, kwad-roo'mă-nah
Quercitron, kwer'sit-ron.
Quito, ke'to.

R.

Radiates, ray'de-ates.
Ramree, ram-re'.
Raptores, rap-to'reez.
Raratongans, rah-rah-tong'ganz.
Rasores, ră-so'reez.
Reggio, red'jo.
Reikianaes, rī'ke-ah-ness.
Rewan, ray-wahn'.
Rhinoceros, ri-nos'e-ros.
Rhododendron, ro-do-den'dron.
Richelieu, re-sheh-lû'.
Riobamba, re-o-bahm'bah.
Rio Virgen, re'o veer'hen.
Rodentia, ro-den'she-ah.
Roraima, ro-rī'mah.
Rotomahana, ro-to-mah-hah'nah.
Ruminantia, roo-me-nan'she-ah.
Rus Detschen, roos det'shen.
Ruska Poyana, roos'kah po-yah'nah.

S.

Saguenay, sahg-e-nay'.
Sahara, sah-hay'rah, *or* sah'hah-rah.
Sala-y-Gomez, sah'lah e go-meth'.
Saltillo, sahl-teel'yo.
Samen, sah'men.
Samoiedes, sam-oy-edz'.
San Diego, sahn-de-ay'go.
Sangar, sahn-gar'.
Sangay, sahn-ghī'.
San Joaquin, sahn ho-ah-keen'.
San José, sahn ho-say'.
Santa Barbara, sahn'tah bar'bah-rah.
Santa Maria, sahn'tah mah-re'ah.
Santorini, sahn-to-re'ne.
Sar'do-Cor'sican.
Saskatchawan, sas-katch'ă-wŏn.
Satpoora, saht-poo'rah.
Sault, sō.
Saurians, saw're-ans.
Sca Fell, skaw'fel.
Scandinavian, skan-de-nay've-an.
Scansores, skan-so'reez.
Schams, shahms.
Schübler, shĕĕb'ler.
Sciacca, shahk'kah.
Scythians, si*th*'e-anz.
Semitic, se-mit'ik.
Seringapatam, ser-ing-gă-pă-tam'.
Shamo, shah'mo.
Siam, si-am'.
Sierra Blanca, se-ĕr'rah blang'kah.
Sierra del Cobre, se-ĕr'rah del ko'bray.
Sierra Leone, se-ĕr'rah le-o'ne.
Sierra Madre, se-ĕr'rah mah'*th*ray.
Sierra Morena, se-ĕr'rah mo-ray'nah.
Sierra Nevada, se-ĕr'rah nay-vah'dah.
Sigillaria, sij-il-lay're-ah.
Sihon, si-hoon'.
Silesia, si-le'she-ah.
Silicious, se-lish'us.
Silicum, sil'e-kum.
Sil'vas.
Simoda, se-mo'dah.
Simoom, se-moom'.
Sir-i-Kol, sīr-e-kol'.
Sirocco, se-rok'ko.
Sitka, sit'kah.
Skaptar Jökul, skahp'tar yö'kööl.
Slavonic, slă-von'ik.
Sneehätten, snay'het-ten.
Solanaceæ, so-lah-nay'she-ee.
Solano, so-lah'no.
Solfatara, sol-fah-tah'rah.
Sorata, so-rah'tah.
Sorghum, sorg'um.
Soudan, soo-dahn'.
Souffrière, soo-fre-air'.
Spa, spaw.
Spinelle, spe-nel'.
Stalactite, stă-lak'tite.
Stalagmite, stă-lag'mite.
Stanovoi, stah-no-voy'.
St. Croix, sent-kroy'.
Steinbok, steen'bok.
Steppes, steps.
St. Gothard, sent got'hart.
Strata, stray'tah.
Stratus, stray'tŭs.
Stromboli, strom'bo-le.
St. Roque, sent roke, *or* ro'kay.
Suadiva, soo-ah-de'vah.
Sudetic, soo-det'ik.
Suliman, soo-le-mahn'.
Sumach, soo'mak.
Sumbawa, soom-baw'wah.
Sumburgh, sum'bŭr-rŭh.
Summa Paz, soom'mah pahz.
Sutlege, sut'lĕj.
Swansea, swon'se.
Syenite, sī'en-ite.
Syriac, sīr'e-ak.

T.

Tacazze, tah-kaht'say.
Tahiti, tah-he'te.
Tamchi-Boulac, tahm-che-boo-lahk'.
Tanganyika, tahn-gahn-ye'kah.
Tangnou, tahng-noo'.
Tapaling, tah-pah-ling'.
Tapioca, tap-e-o'kah.
Tarata, tah-rah'tah.
Tarbagatai, tar-bah-gah-tī'.
Tarifa, tah-re'fah.
Tatra, tah'trah.
Tau, tŏw.
Tchad, chahd.
Tehuantepec, tay-wahn-tay-pek'.
Temblores, tem-blo'rĕs.
Tenasserim, ten-as'seh-rim.
Teneriffe, ten-er-iff'.
Tenochtitlan, tay-nok-tit-lahn'.
Tequendama, tay-ken-dah'mah.
Terek, tay-rek'.
Terra del Fuego, tĕr'rah del foo-ay'go.
Terremotos, tĕr-ray-mo'toce.
Tertiary, ter'she-ă-re.
Teutonic, too-ton'ik.
Thames, temz.
Thian Shan, te-ahn'shahn.
Thibet, tib'et.
Thom, tom.
Tibboos, tib-booz'.
Tibesty, te-bes-te'.
Tierras Calientes, te-ĕr'ras kahl-yen'tĕs.
Tierras Frias, te-ĕr'ras fre'as.
Tierras Templadas, te-ĕr'ras tem-plah'das.
Ti'gris.
Titicaca, te-te-kah'kah.
Tocantins, to-kahn-teens'.
Tolima, to-le'mah.
Toluca, to-loo'kah.
Tomboro, tom-bo'ro.
Torghätten, torg'het-ten.
Torre del Greco, tor'ray del gray'ko.
Torricelli, tor-re-sel'le.
Toucans, too'kans.
Travertine, trav'er-tin.
Trieste, tre-est'.
Trilobite, tri'lo-bite.
Tripoli, trip'o-le.
Tristan d'Acunha, trees-tahn' dah-koon'yah.
Trivanderam, tre-vahn'der-ahm.
Tschudi, tshoo'de.
Tsetse, tset'seh.
Tsien-Tung, tse-en-tung'.
Tufa, tû'fah.
Tulza, tul'zah.
Tunca, tung'kah.
Tundra, toon'drah.
Tunguragua, toong-go-rah'gwah.
Tungusians, toong-goo'se-anz.
Turbaco, toor-bah'ko.
Typhoons, ti-foonz'.

U.

Ucayale, oo-kī-ah'lay.
Udskoi, ood-skoy'.
Ugros, hu'grŏs.
Uleaborg, oo'lay-o-borg.
Ullah Bund, ul'lah-bund'.
Umbagog, um-bay'gog.
Urumiyah, oo-roo-me'yah.

V.

Valais, vah-lay'.
Val Calanea, vahl kah-lah-nay'ah.
Valdai, vahl-dī'.
Valparaiso, vahl-pah-rī'so.
Vasco da Gama, vahs'ko dah gah'mah.
Vasco Nuñez de Balboa, vahs'ko noon'yeth day bahl-bo'ah.
Velino, vay-le'no.
Venezuela, ven-ez-we'lah.
Vent de bise, vŏNG-deh-beez'.
Veragua, vay-rah'gwah.
Via Mala, ve'ah mah'lah.
Victoria Regia, vik-to're-ah re'je-ah.
Vicuña, ve-koon'yah.
Vignone, veen-yo'nay.
Viliui, ve-le-oo'e.
Vindhya, vind'yah.
Vistula, vis'tu-lah.
Vosges, vōzh.
Vulcanos, vool-kah'noce.

W.

Wabash, waw'bash.
Walferdin, wahl-fair-deen'.
Wasatch, wah-satch'.
Wieliczka, v'yay-litch'kah.
Wiljuish, ve-le-oo'ish.
Winnipeg, win'ne-peg.
Winnipiseogee, win-ne-pe-sok'e.
Woad, wōde.
Wold, woald.
Wot'chish.
Wrangell, vrahng'el.
Wul'er.

Y.

Yablonoi, yah-blo-noy'.
Yakoutsk, yah-kootsk'.
Yangling'.
Yang-tse-Kiang, yahng-tse-ke-ahng'.
Yazidees, yahz-e-deez'.
Ybera, e-bay'rah.
Yosemite, yo-sem'e-te.
Youcon, yoo-kŏwn'.

Z.

Zagros, zah'groce.
Zaire, zah-eer'.
Zambezi, zahm-bay'ze.
Zoolitic, zo-o-lit'ik.
Zoology, zo-ol'o-je.
Zoon, zo'on.
Zoophytes, zo'o-fītes.
Zuñi, zoon'ye.
Zwellendam, zwel-len-dahm'.

DATE DUE

~~JUN 21 1978~~

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